SPATIAL ARRANGEMENT AND HARVESTING SCHEDULE IN A SILVIPASTORAL SYSTEM

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

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DECLARATION

I hereby declare that this thesis entitled "Spatial arrangement and harvesting schedule in a Silvi-pastoral system" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
15-02-1989.

SUNIL, P.L.

CERTIFICATE

Certified that this thesis entitled "Spatial arrangement and harvesting schedule in a silvipastoral system" is a record of research work done independantly by Sri.Sunil, P.L. under my guidance and supervision and that it has not previously formed the basis for award of any degree, fellowship or associateship to him.

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We, the undersigned, members of the Advisory Committee of Sri.Sunil, P.L., a candidate for the degree of Master of Science in Forestry with major in Silviculture, agree that the thesis entitled "Spatial arrangement and harvesting schedule in a silvipastoral system" may be submitted by Sri. Sunil, P.L., in partial fulfilment of the requirement for the degree.

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Introduction

1. INTRODUCTION

The problem of availability of forage, fuel and timber wood is getting day by day aggravated mainly because of increased pressure on these commodities due to population increase; both of human and livestock. This has resulted in an indiscriminate exploitation of tree species, which paved way for the deterioration of natural resource producing forage and fuel.

For the existing population, as against 27 million tonnes of milk produced annually, the nutritional requirements call for 50 million tonnes and by the end of 2000 AD, with a projected population of about a billion people, a billion tonnes of milk would be needed. Animal population, meeting the milk and meat requirement of the growing population, will demand for increased forage production. It has been calculated that the fuel wood deficit in the year 2000 would be 59 million tonnes. This problem has to be solved adequately to alleviate rural poverty. In this context, the saying that there may not be famine for food, but of fire wood to cook seems to be true (NCA, 1976). As land resource is limited, its availability for afforestation is also a problem.

Therefore, the need of the hour is an integrated system which would ensure maximum sustained production of multiple produce throughout the year, for which intensive cropping systems are to be practised. The most feasible solution, at present, is to practice such a system an unculturable wastelands, which constitute 10.33% of the total geographical area of India.

Under unculturable wastelands, the silvipasture with top feed/fuel trees of multiple uses in combination with hertaceous pasture plants largely of perennial nature are more desirable (Deb Roy and Pathak, 1974; Patil and Pathak, 1977). This system of utilization of unculturable land is widely accepted and assumes greater economic importance. Silvipastoral system is an intensive cropping system in which grasses are sown or planted in the interspaces of fodder cum fuel trees; in the form of a two-tier system. This system of plantation will serve the population by providing pasturage, fuelwood, conserved hay for the period of scarcity and conservation of soil and water. The important aspect of this system lies in the initial establishment with some inputs; which inturn at different times, singly or in combination, promote the growth of others at different times of the year (Srivastava, 1984). The combinations so selected are to be essentially based on the principle that each of its component draws nutrient from different layers of soil rather than being competitive. Time bound adjustments and pruning of the canopy of each component becomes essential so as to get the balanced growth of different individuals planted in the system.

It may be noted that in such a system; the ideal choice of the species of tree and grass, suited to the particular agroclimatic zone is an important criterion. Leucaena leucocephala (Lam.) de Wit; commonly called Subabul, is reputed for its fast growth rate, protein rich fodder, high calorific value of fuelwood, ability to grow on degraded soils, drought resistance and ability to enrich the soil. This species is widely adapted from 30°S to 30°N and up to an elevation of about 1500 m. It grows in areas with 600 to 1800 mm of annual rainfall (National Research Council, 1984). Guinea grass is suited to be cultivated under such shaded and drought prone conditions (KAU, 1986).

The significance of spatial arrangement of crops and schedule of harvests under such systems; cannot be underestimated. Information on the performance of subabul in the lateritic soils of Kerala, under plantation conditions is totally lacking. Therefore, the identification and popularisation of the best spatial arrangement and harvesting schedule of subabul and guinea grass is essential for providing fodder and fuelwood in the household itself and measures should be adopted to make the best use of waste-lands by bringing them under silvipastoral system of cultivation.

With these aspects in mind, an investigation was undertaken with the following objectives:

i) To find out the most suitable spatial arrangement of subabul and guinea grass, for maximising biomass production.

ii) To ascertain the most suitable harvesting schedule of both subabul and guinea grass.

iii) To investigate the growth characteristic of subabul.

iv) To study the soil fertility aspects; associated with the crops.

Review of Literature

2. REVIEW OF LITERATURE

2.1. Silvipastoral system

King (1979) defined Silvipastoral system as the management of forests both for the production of wood and rearing domesticated animals. The significance of introducing such a system and its many faceted beneficial effects could not be underestimated.

2.1.1. Spatial arrangement and harvesting schedule

A crop combination involving Subabul (*Leucaena leucocephala* (Lam.) de Wit) Var. K-8, as the tree component and guinea grass (*Panicum maximum* (Jacq.) Var. Improved Mackueni, as the grass component was selected due to the following reasons:

Positive attributes of subabul like quick growth, fodder, fuelwood, smallwood and pulp wood value, nitrogen fixing capacity and soil ameliorating properties (NAS, 1977). Brewbaker and Hutton (1979) stated that "hedge rows" could be planted with grass pastures keeping 2 to 4 m between subabul rows. It was found that the legume provided some nitrogen to the associated grass, extending grazing periods late in to the dry season.

Subabul mixes well with guinea grass, either when planted in spaced rows with guinea grass between rows, or in open mixtures. Subabul could be established in rows of 2 or 3 m apart to allow for inter-row mechanical weed control and for maintanence of companion grass forage species. The ability of guinea grass to render good fodder yields under shaded conditions and in limited soil moisture regimes with minimum management makes it the ideal choice for inclusion in silvipastures (KAU, 1986).

Experiments were conducted at Central Arid Zone Research Institute, Rajasthan (Raina, 1983) with four subabul cultivars namely; "Hawaiiam Giant K-8", "Hawaiiam Common", "Peru" and "Cunningham" intercropped with guinea grass. Spacing between subabul was 1.5 x 1.5 m and between guinea grass slips was 34 x 34 cm subabul was cut every 50 day and grasses every 40 days. A combination of Hawaiian Giant K-8/ Cunningham/Peru with the grass gave better yield than the Hawaiian Common - grass combination.

At Indian Grassland and Fodder Research Institute, Uttar Pradesh different fodder yielding trees and grasses were raised under intensive cropping system and the yields estimated (Gill, A.S. and Patel, B.D., 1985). The subabul - guinea grass crop combination gave fresh fodder and dry matter yields of 207900 kg/ha and 55200 kg/ha respectively, while pure subabul stands yielded 105600 kg/ha and 31300 kg/ha of fresh fodder and dry matter respectively. This demonstrated the benefits of subabul - guinea grass association in increased production of fodder grass.

In similar intercropping studies with subabul and guinea grass, Raut and Gill (1987) obtained green fodder and dry matter yields of 120.2 t/ha and 28 t/ha; respectively. These were 8.7% and 4.3% higher than the fresh fodder and dry matter yields from pure guinea grass. It is evident from the above figures that the subabul intercrop benefitted the grass growth.

According to Singh (1987) Leucaena leucocephala (Lam.) de Wit under intercropping system had produced annually 7-8 t/ha of dry nutritions forage; and every three years 8-9 t/ha of firewood without interfering with the crop yield. Thus, there is scope for incorporation of woody perennials like subabul in the crop production systems.

2.1.2. Silvipastoral system - for rearing domesticated animals

Subabul (Leucaena leucocephala Lam.) de Wit) could be combined with Guinea grass (Panicum maximum (Jacq.) in cut and carry systems to provide high yields of nutritious forage. This practice had been used to good advantage for dairy cattle in Hawaii (Humphreys, 1978). According to Brewbaker and Hutton (1979), subabul provided important protein supplement to the animals.

Plucknett (1979) stated that Subabul-Guinea grass mixtures are ideal for zero-grazing; whereby superior, high producing forages which are unsuited for grazing could be used to best advantage by cutting and handling forage to penned livestock. Gohl (1981) found that Subabul-Guinea grass was an excellent mixture for fattening cattle. Such a practice of maintaining permanent improved pastures is prevalent in tropical and subtropical Australia (Wildin, 1985). A practice of establishing Subabul in rows in established grass pastures like Para grass (Brachiaria mutica Stapf.) and Pangola grass (Digitaria decumbens Stent.) had gained wide acceptance there. Inter-planted with Guinea grass, subabul pastures can carry up to 2.5 cattle/ha (National Research Council, 1984).

Reports by Mishra (1986), indicated that subabul through its high N-fixing capacity, which goes up to 500 kg N/ha/year could considerably increase in the yield of many crops when integrated with them.

Though the silvipastural system is primarily considered as the best cropping system for zero-grazing, Pathak and Roy (1987) are of different opinion. According to them the silvipastural system involves production of forage grasses and legumes with multiple purpose trees used initially under cut and carry system (zero-grazing) and later on grazed insitu. To achieve this objective, it is essential to cut back the trees to a height at which the animals can comfortably browse.

2.1.3. Silvipastoral system - for the production of wood

National Research Council (1984) suggested subabul for large scale "energy-plantations" specifically for fuelling brick and charcoal kilns, sawmills, electric generators, railroad locomotives, driers for coconut, fish, tobacco, grain, forage and other agricultural products, facilities processing cassava, sugar or rubber etc. as it has a heating value of about 7000 K cal/kg, which is 70% of the heating value of fuel oil, making it ideal to be used for firewood purpose.

Subabul could serve as a timber in many cases. Subabul wood is strong, dense and attractive and has machining properties comparable to those of many hardwood species. The specific gravity of 6 to 8 year old subabul was found to be 0.54 and this along with other wood properties like tensile, compressive, bending and shear strengths was found to be similar to the same in oak, ash, birch and sugar maple. The wood is fine textured, easily workable, absorbs preservatives and can be treated for protection against termites. It is denser than several fast growing tropical hardwoods such as *Albizia falcataria*, *Gmelina arborea*, *Eucalyptus deglupta* and *Anthocephalus chinensis* which grow with similar rate of growth. Wood yields of 40-50 m^3/ha/year had been reported from some sites. Subabul could be used directly as round wood. Poles thinned from a 2 year old plantation could be used as fence posts, girders, floor joists, rafters for small homes and sheds, propping for banana bunches etc. Subabul could also be a source for minetimbers and railwood sleepers.

Relwani *et al*. (1985) found that Var. K-8 yielded commercial wood of the tune of 126.11 t/ha in a period of 8 years. On another site, the total yield of wood at 75% DM was 59.15 kg/tree, when harvested after 5-7 years.

2.2. Subabul (*Leuceana leucocephala* (Lam.) de Wit)

Subabul is a fast growing multipurpose tree (MPT) native to Central America. The genus consists 10 recognised species of which Leucaena leucocephala (Lam.) de Wit has been exploited extensively. There are more than 800 known varieties; which are broadly classified in to common type, giant type (Salvador type) and Peru type. Some extremely high yielding giant cultivars are K-8, K-28, K-67 etc. of which K-8 is subjected to study in this experiment. Arboreal leuceana-was introduced in India in October, 1976.

In the sub tropical and temperate regions of India, there are large areas of waste lands which are either unproductive or under utilised. A legume like subabul; which can give fodder and fuelwood and withstand frost would be ideal for such conditions (Gupta, 1980).

2.2.1. Growth characteristics

Exceptionally good growth was observed on favourable sites. Though it is now recommended to plant exotics like subabul to increase forest area; the shrubby/bushy leuceanas had been already experimented within Teak plantations of Wynad, Kerala as early as in mid thirties by the Forest Department (Griffith, 1937). Subabul was used as a weed suppressor. It was found that subabul-teak was 11% better than the control Teak in the second year.

Chacko (1984) conducted a study on the root system of five years of trees including subabul commonly grown in Kerala. It was found that in subabul Var. K-28; with a shoot height of 310 cm and GBH (O.B) of 46.3 cm, the horizontal span of its root system was 4.5 m and the root depth was 1.75 m. It was also found that in high rainfall areas and irrigated conditions the root depth was less with a tendency for increased horizontal span.

Bhatia et al. (1985) noticed that total number of branches, branch length and diameter decreased with closer spacings, and this was more noticeable in the lowest (below 2 m height) zone of the plant.

In one of the trials on 3 varieties (K-8, K-28 and K-67) of subabul on two sites in Bangladesh, survival was 96%, 94% and 93% at Charaljam and 89%, 75% and 80% at Keochia for K-8, K-28 and K-67 respectively. Height growth was 63.5, 35.5 and 38.0 cm at Charaljam; 25.5, 22.8 and 20.3 cm at Keochia (Das et al., 1985).

2.2.2. Adaptability to different types of soil

Subabul is reported to grow well in soils of varying textures and growth is best when the pH is neutral to alkaline.

Rao and Khan (1981) in their experiments with subabul on different types of soils observed faster early growth of seedlings on normal soils than on lateritic soils. After two years this difference was negligible. However, germination was not affected by soil conditions as it was as high as 85% in both the cases.

Denton and Nickell (1985) proved that yields from subabul strongly correlated with the amount of soil K. With regard to the topographical effect it was observed that even with high fertility, trees on or near the crest of hills grow much more slowly.

Ta-Wei et al. (1986) indicated that after a forage harvest of subabul; the soil nutrient content had a positive change; which indicated that nutrient gain exceed its removal. This increases the productivity of the site.

Evaluation of subabul accessions for tolerance to soil acidity was conducted on loamy sand at Oboro, South East Nigeria by Coffinia et al. (1987). The surface soil (0-15 cm) at the site had a pH (1:1 soil:water) of 5.0. Based on observations, Var. K-28 was found the best, to be grown on such sites.

2.2.3. Effect of coppicing at different temporal frequencies and cutting regimes on biomass yield production

Various trials have indicated that by adopting varying harvesting schedules and cutting heights, the yield in the form of forage, fuelwood and timber could be regulated.

Das and Dalvi (1981) in their trial in Solapur, Maharashtra demonstrated that cutting at 1 m height above ground and at an interval of 60 days yielded more forage compared to other cutting heights and intervals. Cutting at 1 m height at 90 days interval yielded more fuel wood.

In a different trial maximum forage production was found to be in rainy season and low during dry and cold months (Pathak *et al*., 1981). Reddy and Das (1981) found that Var. Cunningham, when felled after 3 years yielded a dry fuelwood biomass of 12.63 kg/tree and dry forage production of 3.23 kg/tree.

Bhumibhanion and Boonarutee (1984) found that biomass productivity and wood basic density was dependant on spacing, stump size, stump age and site quality.

Under irrigated conditions on fertile loams, subabul could yield nutritious fodder with an average of 27% dry matter and crude protein as dry matter basis (Relwani et al., 1984). For evaluating fodder production, an experiment consisting several cultivars of Leucaena leucocephala were laid out at a spacing 75 x 10 cm, at Urulikanchan, Poona district, Maharashtra (Raina et al., 1984). First cut was taken at 96 days after planting and subsequent cuts on attaining an average shoot length of 125 cm. The initial yield from K-8 was 64500 kg/ha from the first years five cuttings. It picked up growth in the subsequent months giving a yield of 31000 kg/ha in the next two cuts. Mohatkar and Relwani (1985) found that total yield of green foliage increased with stand density and with two cuttings. Firewood yield was greatest (64.5 t/ha) at 20,000 stems/ha, with one forage cutting at 120 cm stubble height. Experiments conducted by Krishnamurthy et al. (1986) on subabul Var. K-63 Hawaiian type (Shrubby) showed that the total forage yield increased significantly with increase in the harvesting interval from 40-70 days; and with increase in stubble height from 15 to 150 cm. It was found that; for forage purposes; it is ideal to harvest between 50 and 60 days at 75 cm cutting height.

Dutt and Urmila (1987) studied the effect of coppicing at different heights for wood production in subabul at a spacing of 1 m x 2 m. Results indicated significant increases in the number of sprouts produced per stump at 25 cm, 50 cm, 75 cm and 100 cm coppicing heights; over coppicing at ground level. For maximising coppiced wood production subabul should be coppiced at heights ranging between 50 and 100 cm.

2.2.4. Root nodulation and Nitrogen fixation

Subabul is leguminous and forms mutually beneficial partnerships with soil bacteria of the genus *Rhizobium*; resulting in the fixation of atmospheric nitrogen. Thus, for average growth subabul require no fertilizer and it can thrive well in nitrogen poor soils.

Root nodulation and growth of *Leucaena leucocephala* in Kerala was experimented by Balasundaram *et al*. (1987). Both nodulation and growth of subabul was found to be poor in soils with low pH (5.5). Inoculation of subabul with *Rhizobium* increased seedling biomass and fresh weight of nodules. At low pH (5.7) fresh weight of nodules and seedling biomass was reduced and as soil pH increased, improvement in both parameters was noticed.

In a comparative study with *Albizia lebbeck*, *Acacia nilotica*, *Dalbergia sisoo* and *Leucaena leucocephala* conducted by the above scientists under pot culture, maximum plant height, nodule biomass and nitrogenase activity was noticed in *Leucaena leucocephala*. The annual fixation by subabul is in the range of 100-200 kg N/ha (National Research Council, 1984).

2.2.5. Fodder value of subabul

Here, subabul foliage as fodder, the toxic effect due to the presence of the alkaloid - "Mimosine" are discussed.

2.2.5.1. Green fodder

There is severe seasonal shortage of protein rich forage in India which has resulted in the poor productivity of the milch animals. Subabul can serve well as a perennial source of forage through the year as it is tolerant to drought conditions.

Gupta *et al*. (1983) found foliage rich in the amino acid Isoleucine and state that it is an ideal green fodder for ruminant species of animals. The subabul-protein is of high nutritional quality as its amino-acids are well balanced. The leaves are a rich source of Vitamins, carotenes, calcium, phosphorus and other dietary mineral nutrients. The "in-vivo" digestibility of subabul leaves and stems is between 50 to 70%, subabul incorporated pastures had recorded higher milk yields than those achieved on other legume - based tropical pastures

(National Research Council, 1984). In experiments on 18 cultivars of subabul Lahane et al.(1987) found that the crude protein content varied between 26.3 to 27.1%.

2.2.5.2. Toxic effect and its detoxification

Subabul contains the aminoacid, "mimosine", which cause hair loss and affected fetal development in non-ruminants. The mimosine concentrations in the subabul strains ranged between 3-5% of the dry matter. Microbes in the first stomach (rumen) of ruminants convert mimosine in to another compound 3,4-dihydroxy pyridine (DHP), which is further broken down to non-toxic compounds. In countries such as Australia, Papa New Guinea and Africa where the requisite microbes are reported to be absent the DHP is not degraded. In such cases, it lead to goitre (enlargement of thyroid glands), animals became listless, their appetites and weight gains were depressed; they produced excessive saliva and body hairs fell out. However, even in such places feeding subabul up to 30% of the diet was safe for the cattle (National Research Council, 1984).

The mimosine present in subabul foliage could be detoxified by various treatments. It was found that moist heating of the foliage at 70-100°C for 72 hours or steaming for 2 hours reduced mimosine content by 50%. Putting the fresh fodder under sun for a couple of hours reduced mimosine content. Addition of Ferrous Sulphate 0.02% on dry basis also reduced the mimosine toxicity as the iron salt hinders the absorption of mimosine and helps in its excretion in faeces (Gupta *et al.*, 1983).

At Chammanampathi, Pollachi Taluk, Tamil Nadu, the practice of mixed farming had been reported, where goats are maintained in subabul plantations (Varghese, 1987). The sole diet of the goats are the seedlings of subabul, as there is very good natural regeneration from the fallen seeds. Good live weight gain were observed in these subabul-fed goats without any ill-effects.

2.2.6. Miscellaneous uses of subabul

The use of subabul as leaf meal, leaf manure and as pulp wood is also reported.

2.2.6.1. Leaf meal

Subabul leaf-meal contains proteins, minerals and vitamins and it an ideal poultry feed. An addition of 4-6% subabul leaf-meal in the poultry diet restored health of chicks suffering from Vitamin-A deficiency and the cartoenes made the egg yolk and broiler skins yellow.

2.2.6.2. Leaf-manure

Evaluation of different forage shrubs including *Leucaena leucocephala* as a source of leaf manure at Indian Grassland and Fodder Research Institute (IGFRI), Jhansi by Gill and Patil (1984) demonstrated that leaves of leguminous fodder shrubs could be an excellent source of manure and among them subabul was the most promising source.

2.2.6.3. Pulpwood

Subabul wood processes satisfactorily, producing pulps high in holocellulose and low in silica, ash, lignin, alcohol-benzene solubles and hot-water solubles. The low lignin content is an economic advantage. Pulp yield is 50-52%; which is high. The paper has high opacity and printability, is well suited for printing and writing. Subabul hard wood could be used for manufacturing fibre board (National Research Council, 1984).

2.3. Guinea grass (*Panicum maximum* (Jacq.))

This is a perennial grass native to Africa and introduced to India in 1793. It can grow under partial shade with little effect on its yield. It gives fodder round the year. Being a perennial, the grass once planted remains in the field for

4 to 5 years and saves the cost of repeated tillage, sowing and seeds. Unlike hybrid Napier, it can be fed to cattle without any untoward effect.

2.3.1. Effect of cutting frequency on growth and yield

The effect of clipping on rate of tillering was studied by many scientists. The clipping of stem apexes stimulated tillering by removing the major source of auxin which inhibited lateral bud development and consequently the lateral buds were free to develop (Leopold, 1949; Cook and Stoddart, 1953). Maeda and Ehara (1962) observed initial severe defoliation at 2 cm height caused the death of many tillers and initial decrease in number of new tillers followed by a large increase compared to unclipped control. In grasses, the maximum yield is reported at the first cut. Increased frequency of cutting reduces the yield. This phenomenon is linked with the uninterrupted stem elongation, inflorescence development, and higher growth rates. Frequent cutting generally reduces total dry matter production, where as the percentage of digestible dry matter may be increased by increasing cutting frequency (Humphreys, 1966; Williams, 1980).

2.3.2. Tiller development

The tillers arising on the main stem of the seedling are known as primary tillers, there produce the secondary tillers and so on. Garwood (1969) found that tillering rate was least before and after flowering; it then increased through the summer in to autumn declined in winter and then increased rapidly in spring.

Tiller development is influenced by factors like high light intensity, optimum temperature, availability of major nutrients N, P and K. The numbers of tillers per unit area are at their maximum at the end of the vegetative period. Such annual fluctuations are evident irrespective of frequency of cutting or grazing or harvesting for seed, but in any year differences occur as a result of differences in weather and growing conditions (Williams, 1980).

2.3.3. Effect of light on growth

Langer (1963); Davis and Lande (1964); Anda *et al.* (1966) observed that even if there is no defoliation, stimulation of tillering could result from creation of favourable light environment for tillering. It was also found that tillering was reduced by low light intensity. With regard to the critical leaf area index (CLAI), which is the point of maximal growth and interception of about 95% of the incident light (Humphreys, 1966) to be about 4.0 for the guinea grass.

Williams (1980) state that the development of tillers from the axillary buds is much increased by increasing light intensity, but variation in light intensity has tiller influence on the rate of leaves produced. The quantity of light energy received by a sward of grass is important with regard to dry matter production. The efficiency with which light energy is converted by the grass sward depend on the photosynthetic activity on individual leaves, their arrangement within the crop and the proportion of light energy falling on a given area that is intercepted by green leaves. Leaves of temperate grasses attained light saturation from 20,000 to 30,000 lux and did not respond to higher light intensities. It was also found that the optimum LAI may range from 3 to 9.

Materials and Methods

3. MATERIALS AND METHODS

A field experiment was carried out under Silvipastoral system of cultivation with the main objective of determining fodder yield under different spatial arrangement and harvesting schedule of the crops involved. The trial was conducted at the Social Forestry plantation (12° 32' N latitude and 74° 21' E longitude) of the Kerala Forest Department located at Viyoor Central Jail compound which is 6 km away from Trichur town, on the Shornur Road.

3.1. Materials

3.1.1. Site characteristics: Prior to the establishment of the subabul plantation in 1984 the area was a waste land with full of rank growth.

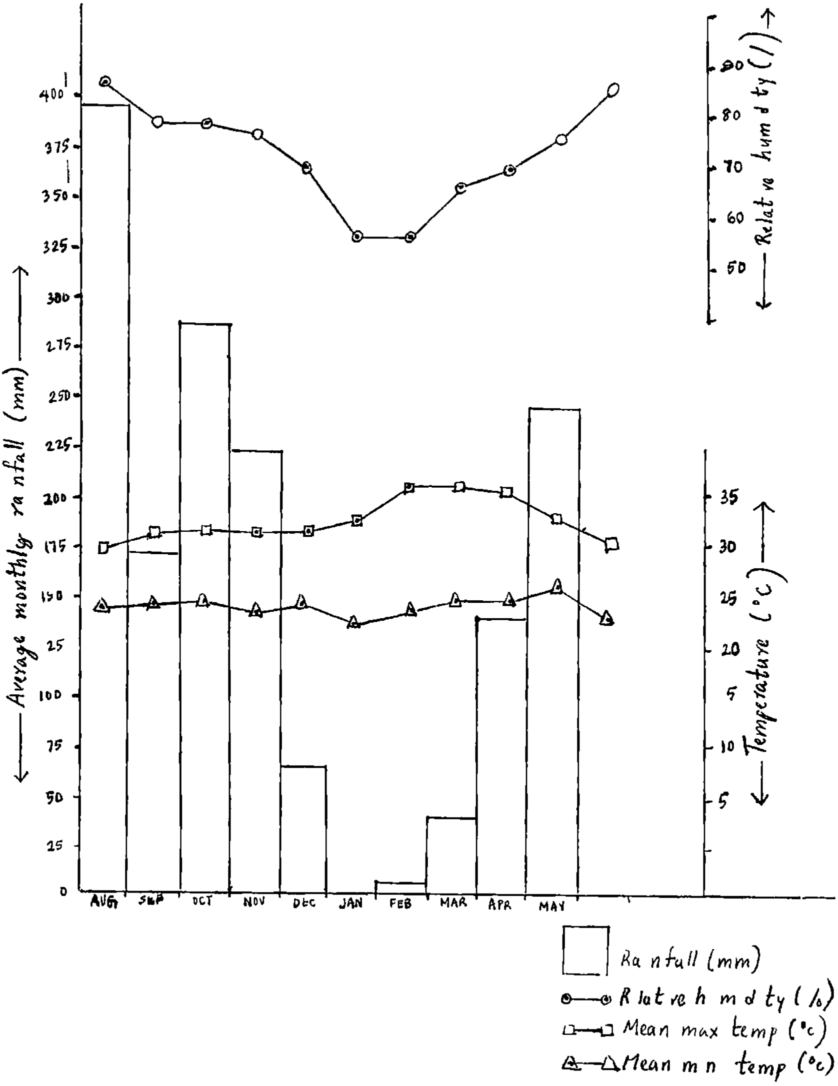
3.1.2. Climate: The area had a humid tropical climate. Monthly average values of meteorological parameters observed during the period of experiment are furnished in Table 1 and Figure 1.

3.1.3. Soil characteristics: The soil in the experimental area was shallow, well drained and acidic with pH 5.5. Composite soil samples from 0-15 cm depth and 15-30 cm depth were drawn before and after the experiment, which was subjected to chemical analysis for determining organic carbon available N, P, K and pH.

Table 1. Meteorological data for the experimental period

Year/month		Total rainfall (mm)	Mean maximum temperature (%)	Mean minimum temperature (%)	Relative humidity (%)	No. of rainy days
1987	August	388.4	29.6	23.5	87	22
	September	174.0	31.5	23.9	79	8
	October	280.4	31.9	23.9	79	16
	November	224.4	31.6	22.8	77	6
	December	64.6	31.6	23.3	70	6
1988	January	0	32.4	22.0	56	0
	February	7.80	35.8	23.1	56	1
	March	37.90	35.7	24.4	67	2
	April	145.40	35.1	24.3	70	9
	May	242.60	33.7	25.4	76	6
	June	632.1	30.0	23.7	86	25

Fig 1 METEOROLOGICAL OBSERVATIONS DURING EXPERMENTAL PERIOD



3.1.4. Crops: The experiment involved a tree species (*Leucaena leucocephala* (Lam.) de wit) and a grass species *Panicum maximum* Jacq. Subabul belonged to Hawaiian Giant Var. K-8 and the Guinea grass was an improved Mackueni variety.

3.1.5. Experimental period: The experiment was conducted during August 1987 to June 1988.

3.2. Methods

3.2.1. Experiment technique

Lay out of the experiment:

Design : Factorial RBD

Plot size : 10.4 x 10.4 m^2

Lay out is given in Fig.2

3.2.2. Treatments:

i) Spatial arrangements:

1. 1.5 m between subabul rows and five rows of guinea grass in the alleys between two rows of subabul.
2. 3 m between subabul and ten rows of guinea grass between 2 rows of subabul.
3. Subabul pure crop at 3 x 3 m spacing
4. Subabul pure crop at 1.5 x 1.5 m spacing
5. Guinea grass pure crop; at 36 x 18 cm spacing

ii) Harvesting schedules:

1. Harvesting both Subabul and guinea grass simultaneously once in 2 months.
2. Harvesting Subabul every second month and Guinea grass 15 days earlier.
3. Harvesting Subabul every second month and Guinea grass 15 days later.
4. Harvesting Subabul every second month and Guinea grass every 45th day.

Buffer strips or surrounds of 3 m width were maintained around all plots. Plot lay-out with spacing details of the tree and the grass are presented in Fig. 2 and Plates.

3.2.3. Field management:

i) Preparation of main field: The experimental area was initially knife-weeded. The entire area was then thoroughly tilled with spade and plant debris removed. Plots were formed as per experimental design and ridges taken for planting grass.

ii) Planting and spacing:

a) The 4 year old subabul plantations raised by the Forest Department was used for the trials. The plantations had an espacement of 1.5 x 1.5 m and 3 x 3 m in adjoining bits.

Fig 2 PLAN OF LAYOUT

$H\ S_1 R_1$	$H_4 S_1 R_1$	$H_2 S_1 R_3$
$H_3 S\ R_3$	$H\ S_1 R_2$	$H_3 S\ R$
$H_2 S_1 R_2$	$H_3 S\ R_2$	$H_4 S\ R_3$
$H_1 S\ R_3$	$H_4 S\ R_2$	$H\ S\ R_2$

SURROUND

$14 S_4 R$	$H_3 S_4 R_3$	$H_3 S_4 R$
$H_2 S_4 R$	$H\ S_4 R$	$H_2 S_4 R_2$
$H_1 S_4 R_2$	$H_3 S_4 R_2$	$H_4 S_4 R_2$
$H_4 S_4 R_3$	$H_1 S_4 R_3$	$H_2 S_4 R_3$

SURROUND

$H_4 S_2 R_2$	$H_3 S_2 R_2$	$H_2 S_2 R_1$
$H\ S_2 R_3$	$H\ S_2 R_1$	$H_4 S_2 R_3$
$H_2 S_2 R_2$	$H_4 S_2 R$	$H_3 S_2 R_1$
$H_3 S_2 R_3$	$H\ S_2 R_2$	$H_2 S_2 R_3$

SURROUND

$H_4 S_5 R_3$	$H_2 S_5 R_2$	$H_3 S_5 R$
$H_4 S_5 R$	$H_3 S_5 R_3$	$H_4 S_5 R_2$
$H\ S_5 R$	$H_1 S_5 R_2$	$H_2 S_5 R_1$
$H_2 S_5 R_3$	$H_3 S_5 R_2$	$H\ S_5 R_3$

SURROUND

$H_3 S_3 R_2$	$H_3 S_3 R_1$	$H_1 S_3 R$
$H_2 S_3 R_2$	$H_4 S_3 R$	$H\ S_3 R_3$
$H_2 S_3 R_3$	$H_3 S_3 R_3$	$H_4 S_3 R$
$H_2 S_3 R$	$H_4 S_3 R_2$	$H\ S_3 R_2$

SURROUND

Treatments 20
Repl cations : 3
Jes gn Factor al RBD
Net Plot S ye : 10 4 x 10 4 M^2

$H\ H_2\ H_3\ H_4$ Harvesting schedules
$S_1\ S_2\ S_3\ S_4\ S_5$ Spatial arrangements.
$R\ R_2\ R_3$ Repl cations

Plate 1. Subabul at 3x3 m spacing, intercropped with guinea grass

Plate 1

Plate 2

Plate 3. Subabul at 1.5 x 1.5 m spacing, intercropped with guinea grass

Plate 4. Intercropped subabul at 1.5 x 1.5 m spacing, 30 days after pollarding the trees

Plate 3

Plate 4

Plate 5. Pure crop of subabul at 1.5x1.5 m spacing

Plate 6. Pure crop of subabul at 3x3 m spacing

Plate 5

Plate 6

Plate 7. Pure crop of guinea grass

Plate 8. Subabul and grass within the roped area represent a treatment

Plate 7

Plate 8

b) Guinea grass slips were planted @ 2-3 slips per hill at a spacing of 36 x 18 cm.

iii) Manuring: The crops were manured as per the Package of Practices recommendations of KAU, 1986 (KAU, Package of Practices 1986).

iv) Weeding and interculturing: Weeding was done in all the plots in the initial stages at fortnightly intervals. During the later stages weeding was not found necessary as the dense grass cover suppressed weed emergence.

v) Harvesting: Subabul and Guinea grass were harvested as per the prescribed harvesting schedule. The first harvest of Subabul was carried out by giving a 45° slanting cut at 1.5 cm height (Figure 2). In subsequent harvests where coppice shoots were harvested a sharp knife was used. The guinea grass was harvested at a height of 5 cm above the ridge level and the fresh weight determined, using a spring balance.

3.2.4. Biometric observations

3.2.4.1. Growth of subabul

The growth characteristics of a four year old subabul plantation was observed at monthly intervals. Growth parameters observed and recorded were;

i) Total height of trees

ii) Girth at Breast height

iii) Girth at collar

5 random trees were selected from the following spacing and crop combinations for observation.

1) 3 x 3 m Subabul-Guinea grass irrigated intercrop
2) 1.5 x 1.5 m Subabul-Guinea grass irrigated intercrop
3) 3 x 3 m Subabul - irrigated pure crop
4) 1.5 x 1.5 m Subabul - irrigated pure crop

(i) Total height of trees:

The total height of the standing tree was measured in metres correct to first decimal place, using a straight wooden pole of 7 m height (FRI Abridged Glossary of Technical Terms, 1983).

(ii) Girth at Breast Height:

The over bark girth measurements of standing trees were taken at a height of 1.37 m from ground level using a tape. A straight pole of 1.37 m height was used to mark the breast height of the tree. The measurements were recorded in cm correct to 1 mm.

(iii) Girth of collar:

The girth measurements of standing trees just above the ground (transition zone between stem and root) were taken using a tape.

3.2.4.2. Growth of guinea grass

The growth parameters observed and recorded were

i) Total height of the hill
ii) Number of tillers per hill
iii) Total number of leaves
iv) Total number of fully folded leaves (Mature leaves)
v) Total number of unfolded leaves (young leaves)

Five hills each were selected at random from the 3 x 3 m Subabul-Guinea grass plot, 1.5 x 1.5 m Subabul-Guinea grass plot and Guinea grass pure plot and observations taken at weekly intervals.

3.2.5. Biomassmeasurements

3.2.5.1. Subabul

(i) The girth at breast height (g) of all the trees in each plot was measured and converted in to diameter at breast height (d) using the relationship $d = 2 \pi / g$. The trees were grouped in to three diameter classes and the diameter totalled for each group. The total diameter of the group was divided by the total number of trees to arrive at mean diameter of that group. A tree having diameter close to mean diameter was felled as a sample tree for this group. Similarly other two mean trees are also selected for felling.

(ii) All the three mean trees were felled used saw at ground level and green weights determined using a spring balance. The samples were collected in polythene bags for determining the green-ovendry weight ratio.

(iii) The total length of the tree from base to the tip was measured and recorded. The points (including big branches) at the tip of the tree where the diameter over bark (d.o.b) is 5 cm were marked. Portions having more than 5 cm d.o.b. and less than 5 cm d.o.b. were designated as "stem wood" and "small wood" respectively. Crown length and width were also measured.

(iv) The bole was cut at 5 cm d.o.b. by saw and length measured. Marked points at 1 m length intervals from the base towards tip. Removed all branches from bole and cut the point at 5 cm d.o.b. in branches also and kept the stem wood of bole and branches together.

(v) Leaves with petiole were removed from all the branches, weighed and recorded.

(vi) All branches less than 5 cm d.o.b. (small wood) were weighed.

(vii) 1 m billets prepared were weighed.

(viii) The diameter of each 1 m billet was measured at base, mid-point and topend o.b. and recorded.

(ix) A 5 cm thick disc from the 1 m billets was removed at the base (with bark) and weighed.

(x) The above procedure was repeated for all 1 m billets prepared from average trees.

(xi) Diameter measurements were taken for the stem wood branches at base, midpoint and top (o.b.) and weighed with bark. 5 cm thick disc were taken at the base.

(xii) The discs were serially numbered from base to tip for easy identification. They were kept in seperate polythene bags, duly numbered the 100 g leaves, branch wood, small wood, fruits and flowers etc. for carrying it to laboratory and the oven dry weight was found.

(xiii) Since, moisture content in wood vary, due to climatic variations only oven dry weight was taken for all estimations.

(xiv) The samples of the mean tree were kept seperately in the laboratory for oven drying at 85°C till the dry weight is constant and oven dry weight of the entire bole, total leaves, total fruits were determined (Kushalappa, K.A. 1984).

3.2.5.2. Guinea grass

Based on the growth observations of sample hills, those with average growth were identified. These were uprooted and fresh weight of shoot (above ground portion) taken. The samples were oven dried at 85°C till the dry weights were constant.

3.2.6. Light intensity

Light intensity observations were carried out in the following plots at a height of 70 cm above ground level, at monthly intervals.

1. 3 x 3 m Subabul - Guinea grass plot
2. 1.5 x 1.5 m Subabul - Guinea grass plot
3. 3 x 3 m Subabul pure plot
4. 1.5 x 1.5 m Subabul pure plot
5. Pure Guinea grass plot

The lux was read in the 300 Lux range mode using filters which were calibrated. The readings were taken during day time on days of clear sunshine, at mean standard times 10.20 A.M., 12.20 P.M., 2.20 P.M. and 4.20 P.M. For this purpose, the experimental plot was divided into three squares (Fig. 3).

1. Experimental plot itself - 10.4 x 10.4 = 1081.6 m^2
2. Smaller square - 6.004 x 6.004 = 36.05 m^2
3. Smallest square - 3.46 x 3.46 = 12.02 m^2

While taking observations the observer faced south with the light sensor held in a horizontal position facing upwards. The sensor was then moved in an arc slowly and repeatedly so as to obtain maximum and minimum values of lux obtained at that point and the average of the two values were recorded. The observations were taken at the positions A, B, C, D, E, F, G, H in all the 3 squares in a plot and a reading was also taken at the centre. The procedure was repeated for all the plots and the observations were recorded (Fig. 3).

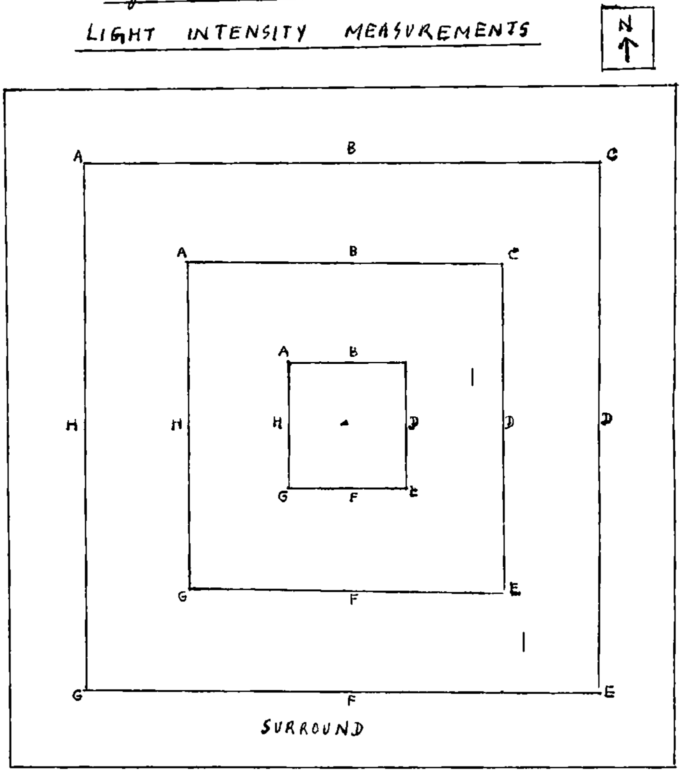
3.2.7. <u>Chemical analysis</u>

i) <u>Chemical analysis of soil</u>:

Composite soil samples were taken from each plot prior to the sowing of fodder legumes as well as after the harvest

Fig 3 METHODOLOGY OF

LIGHT INTENSITY MEASUREMENTS



of the crops. Samples were taken at two depths viz. 0-15 cm and 15-30 cm. The soil samples were then air-dried, powdered and sieved through a 2 mm sieve.

a) Organic carbon

Walkley and Black method (Jackson, 1958) was used for the determination of total organic carbon content of soil.

b) Available phosphorus

Available phosphorus content of the soil was determined using Bray I extractant and molybophosphoric acid method in hydrochloric acid system (Jackson, 1958).

c) Available potassium

The available potassium content of soil was determined flame photometrically, using the neutral normal ammonium extract (Jackson, 1958).

d) pH

The pH of the soil was determined in a 1 : 2.5 soil-water suspension using a pH meter.

3.2.8. Statistical analysis

Data relating to each character were analysed statistically on an electronic computer. The 'F' test was carried out by analysis of variance technique (Panse and Sukhatme, 1978). Significant results were compared after finding out the critical differences.

Results and Discussion

4. RESULTS AND DISCUSSION

The results of the studies on the effect of spatial arrangement and harvesting schedule in a silvipastoral system are presented and discussed in this chapter.

4.1. Green fodder yield

4.1.1. First season: November-December

The data on the mean green fodder yield obtained for each harvesting schedule corresponding to the various spatial and crop combinations for the first season are presented in Table 2. Each value corresponds to the yield obtained during a period of two months per 9 sq.m. Significant variation was observed between the different spatial combinations. Among the spatial and crop combinations, subabul planted at 1.5 x 1.5 m spacing, intercropped with guinea grass recorded the maximum yield of 5.42 kg followed by subabul at 3 x 3 m spacing, intercropped with guinea grass (4.83 kg), pure guinea grass (3.35 kg), pure subabul planted at 1.5 x 1.5 m spacing (2.05 kg) and pure subabul at 3 x 3 m spacing (0.9 kg) respectively. There was no significant difference between the various harvesting schedules.

4.1.2. Second season: January-February

The mean green fodder yield for the second and third season are presented in Tables 3 and 4 respectively. Significant variation was observed between different spatial and crop combinations for the second season. Subabul planted at 1.5 x 1.5 m spacing intercropped with guinea grass recorded the highest green fodder yield (5.63 kg), which was on par with that obtained for subabul at 3 x 3 m spacing intercropped with guinea grass, (5.40 kg). This was followed by pure guinea grass (4.36 kg), pure subabul planted at 1.5 x 1.5 m spacing (1.17 kg) and pure subabul planted at 3 x 3 m spacing (0.46 kg), respectively. Significant variation was also observed among the different harvesting schedules. The two harvesting schedules in which subabul was harvested every two months and guinea grass for 15 days earlier (H-2) and the other in which subabul was harvested every two months and guinea grass 15 days later (H-3), recorded the highest green fodder yield (3.89 kg), followed by the harvesting schedule in which subabul and guinea grass were harvested simultaneously, (H-1) once in two months (3.54 kg) and the harvesting schedule in which subabul was harvested every second month and guinea grass (H-4) every 45th day (2.3 kg) respectively.

Table 2. Mean green fodder yield (kgs) - December 1987*

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	S-4	S-5	Mean
H-1	4.81	0.92	3.33	4.98	2.28	3.27
H-2	5.20	0.58	3.20	5.20	2.05	3.25
H-3	4.77	1.43	3.37	5.78	2.49	3.57
H-4	4.55	0.67	3.50	5.70	1.38	3.16
Mean	4.83	0.9	3.35	5.42	2.05	

Spatial arrangement : S Harvest schedule : NS
C.D. at 5% level : 0.494
SEm : 0.358 *Yield per 9 m^2

Table 3. Mean green fodder yield (kgs) - February 1988*

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	S-4	S-5	Mean
H-1	6.21	0.36	4.07	5.94	1.12	3.54
H-2	6.36	0.41	4.80	6.71	1.15	3.89
H-3	6.02	0.65	5.13	6.24	1.39	3.89
H-4	3.00	0.43	3.43	3.63	1.02	2.30
Mean	5.40	0.46	4.36	5.63	1.17	

Spatial arrangements : S Harvest schedule : S
C.D. at 5% level : 0.248 C.D. at 5% level : 0.222
SEm : 0.09 *Yield per 9 m^2

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Pure subabul planted at 3x3 m spacing
S-3 - Pure guinea grass
S-4 - Subabul planted at 1.5x1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-5 - Pure subabul planted at 1.5x1.5 m spacing

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass at 45 days intervals

4.1.3. Third season: March-April

From the data presented in Table 4 regarding the green fodder yield for the third season, it can be observed that there is significant variation among spatial arrangements and harvesting schedules. Comparing among the spatial arrangements, subabul planted at 1.5 x 1.5 m spacing intercropped with guinea grass recorded the maximum yield (6.70 kg), followed by subabul planted at 3 x 3 m spacing intercropped with guinea grass (6.26 kg); pure guinea grass (4.94 kg); pure subabul planted at 1.5 x 1.5 m spacing (1.61 kg); and pure subabul planted at 3 x 3 m spacing (0.75 kg) respectively. Comparing among the harvesting schedules the highest green fodder yield was obtained for the harvesting schedule in which subabul was harvested (H-2) every second month and guinea from 15 days earlier (4.32 kg); which was on par with that in which subabul was harvested (H-3) once in two months and guinea grass 15 days later (4.22 kg) and in which subabul and guinea grass were harvested simultaneously (H-1) once in two months (4.03 kg). The harvesting schedule (H-4) in which subabul was harvested every second month and guinea grass at 45 days intervals gave an yield of 3.64 kg; which was significantly lower than the others.

Table 4. Mean green fodder yield (kgs) - April 1988*

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	S-4	S-5	Mean
H-1	6.29	0.67	5.00	6.39	1.77	4.03
H-2	6.42	0.79	5.75	7.22	1.43	4.32
H-3	6.27	0.84	5.37	6.57	2.03	4.22
H-4	6.06	0.67	3.63	6.64	1.20	3.64
Mean	6.26	0.75	4.94	6.70	1.61	

Spatial arrangement : S
C.D. at 5% level : 0.362
SEm : 0.192

Harvest schedule : S
C.D. at 5% level : 0.324
*Yield per 9 m^2

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Pure subabul planted at 3x3 m spacing
S-3 - Pure guinea grass
S-4 - Subabul planted at 1.5x1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-5 - Pure subabul planted at 1.5x1.5 m spacing

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass at 45 days intervals

4.1.4. Discussion

From the data regarding the mean green fodder yield obtained for the three seasons, it could be seen that the green fodder yield was obtained in the following descending order of spatial arrangement viz. subabul at 1.5 x 1.5 m spacing intercropped with guinea grass, subabul at 3 x 3 m spacing intercropped with guinea grass, pure guinea grass, pure subabul at 1.5 x 1.5 m spacing and pure subabul at 3 x 3 m spacing, respectively. It was found that the intercropped plots recorded higher fodder yield compared to others. This conforms to the results obtained by Raina (1983), Gill and Patil (1985) and Raut and Gill (1987), that subabul-guinea grass crop combination yielded better green fodder than the monocrop of each species. With regard to the harvesting schedules, subabul harvested (H-3) once in two months and guinea grass 15 days later gave highest yield (3.57 kg) for the first season. For the second season yields from subabul harvested (H-3) once in two months and guinea grass 15 days later and subabul harvested (H-2) once in two months and guinea grass 15 days earlier, were on par (3.89 kg). In the last season, subabul harvested (H-2) once in two months and guinea grass 15 days earlier gave highest yield (4.32 kg). In the above mentioned two harvesting schedules, an overlapping cycle of growth and period of harvest exist and this may be the season for higher green fodder yields corresponding to these harvesting schedules.

4.2. Height of grass

4.2.1. Comparison between first and second season

The data on the rate of increase in height (%) of guinea grass in the second season (November-December) compared to the first season (September-October); for each harvesting schedule corresponding to the different intercropped and pure plots; are presented in Table 5. Significant variation was noticed among the grass planted in the two subabul plots; as well as the pure crop. The grass intercropped in the subabul plot (subabul planted at 3 x 3 m spacing), showed the maximum rate of increase in height (28.02%); followed by the grass intercropped in the other subabul plot (subabul planted at 1.5 x 1.5 m spacing), which showed an increase of 26.71% and pure guinea grass (22.47%), respectively. The rate of increase (%) in the parameter obtained for the first two intercropped treatments were found to be on par; while it differed significantly from the pure grass treatment. The four harvesting schedules were also found to vary significantly. It can be seen from the table that the maximum rate of increase in height was obtained for the harvesting schedule (H-2), in which subabul was harvested every second month and guinea grass 15 days earlier (32.52%); followed by the harvesting schedule (H-1), in which both subabul and guinea grass, were harvested simultaneously once in two months (27.70%); and the harvesting schedule (H-3); in which subabul was harvested every second months and guinea grass 15 days later (27.21%). The rate of increase in height obtained for the H-1 and H-3 harvesting schedules were found to be on par; while this was significantly lower compared to that obtained for the H-2 harvesting schedule. The least and significantly lowest rate of increase was recorded for the H-4 harvesting schedule in which the grass was harvested at 45 days intervals (15.48%). The interaction effect between crop combinations and harvesting schedule was found insignificant.

4.2.2. Comparison between second and third season

Data on the rate of increase in height (%) in the third season (January-February), compared to the second season (November-December) are given in Table 6. Significant variation was observed for the grass in the intercropped plots (39.20% and 39.10%) was on par and was significantly higher compared to the pure grass (30.39%). The different harvesting

Table 5. Comparison of percentage increase in height of grass between October and December 1987

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	30.78	30.24	22.08	27.70
H-2	35.47	34.34	27.76	32.52
H-3	28.14	27.29	26.20	27.21
H-4	17.68	14.95	13.83	15.48
Mean	28.02	26.71	22.47	

Spatial arrangement : S   Harvest schedule : S
C.D. at 5% level : 2.156   C.D. at 5% level : 2.490
SEm : 6.487

Table 6. Comparison of percentage increase in height of grass between December 1987 and February 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	40.05	41.97	31.73	37.92
H-2	45.67	44.58	32.85	41.03
H-3	40.50	40.50	34.48	38.49
H-4	30.59	29.20	22.49	27.43
Mean	39.2	39.10	30.39	

Spatial arrangement : S   Harvest schedule : S
C.D. at 5% level : 2.154   C.D. at 5% level : 2.487
SEm : 6.472

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Subabul planted at 1.5x1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-3 - Pure guinea grass

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass at 45 days intervals

schedules also showed significant variation. The harvesting schedule (H-2), in which subabul was harvested every second month and the grass 15 days earlier topped in the rate of increase in height (41.03%) and this was significantly higher than the other schedules. The rate of increase for the H-3 harvesting schedule in which subabul was harvested every second month and guinea grass 15 days later (38.49%) and H-1 harvesting schedule in which subabul and grass were harvested simultaneously every second months (37.92%) were on par. The 27.43% rate of increase obtained for the H-4 harvesting schedule in which guinea grass was harvested every 45th day was significantly lower compared to others. The interaction effect for the crop combinations and harvesting schedules was found significant.

4.2.3. Comparison between third and fourth season

In Table 7 data on the same parameter in the fourth season (March-April) compared to the third season (January-February) are presented. The variation for the grass between the pure and intercropped plots was found significant. Here also the intercropped plots had a superior rate of increase (39.31% and 39.35%); which was on par with each other, compared to that obtained for pure guinea grass (29.73%). Significant variation was also observed for the harvesting schedules.

The rate of increase for the harvesting schedule (H-3) in which subabul was harvested every second month and guinea grass 15 days later (39.32%) along with that obtained for H-1 harvesting schedule in which both subabul and guinea grass was harvested every second month simultaneously (39.07%) was found to be superior over others; and was as par with each other. This was followed by the H-2 harvesting schedule in which subabul was harvested every second month and the grass 15 days earlier (39.02%). This was found to be on par with the value obtained for H-1 harvesting schedule. A significantly low value of 27.10% was obtained for the H-4 harvesting schedule in which the grass was harvested at an interval of 45 days. The interaction effect was found insignificant.

4.2.4. <u>Comparison between fourth and fifth season</u>

Data regarding the comparison of rate of height of grass between the fifth season (May-June) and the preceding season (March-April) are presented in Table 8. There was significant variation among the intercropped and pure grass treatments. As in the earlier comparisons; the intercropped grass treatments was found to be superior (34.42% and 34.70%) and was on par with each other. A significantly low value

Table 7. Comparison of percentage increase in height of grass between February and April 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	42.86	42.48	31.87	39.07
H-2	43.71	44.54	28.80	39.02
H-3	42.11	41.98	33.88	39.32
H-4	28.57	28.39	24.35	27.10
Mean	39.31	39.35	29.73	

Spatial arrangement : S   Harvest schedule : S
C.D. at 5% level : 4.596   C.D. at 5% level : 5.306
SEm : 19.458

Table 8. Comparison of percentage increase in height of grass between April and June 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	37.92	41.13	29.43	36.16
H-2	31.03	28.93	25.75	28.57
H-3	39.65	40.52	35.24	38.47
H-4	29.09	28.23	26.70	28.00
Mean	34.42	34.70	29.28	

Spatial arrangement : S   Harvest schedule : S
C.D. at 5% level : 3.428   C.D. at 5% level : 3.958
SEm : 16.388

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Subabul planted at 1.5x1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-3 - Pure guinea grass

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass, at 45 days intervals

of 29.28% was obtained for the pure grass treatment. The harvesting schedules treatment also showed significant variation. The rate of increase in height for the H-3 harvesting schedule (38.47%), was on par with the obtained for the H-1 harvesting schedule (subabul and grass harvested simultaneously once in two months) (36.16%). This was significantly superior to other schedules. The parameter for the H-2 harvesting schedule in which subabul was harvested every second month and the grass 15 days earlier (28.57%) and that obtained for the H-4 harvesting schedule (grass harvested at 45 days interval)(28.00%) was on par. The interaction effect was insignificant.

4.2.5. Discussion

The rate of increase in height (%) of guinea grass decreased in the pure grass plot compared to the intercropped plots (See Tables 5, 6, 7 and 8). This reduction in height growth could be attributed to the increased rate of tillering (See Table 9, 10, 11 and 12) that take place under high light intensity conditions. Auda et al., Humphreys (1966) and Williams (1980) found that the synthesised food materials under high light intensity conditions are utilised more in producing new tillers, than increasing the height of existing tillers. Thus the reduction in height of pure guinea grass may be due to the enhanced rate of tillering.

The percentage rate of increase in height for the harvesting schedules of the different seasons, when compared, reveal the following pattern. During the first two harvests, the rate of increase in height was more for the H-2 harvesting schedule (subabul harvested at two month intervals and guinea grass 15 days earlier). In this harvesting schedule as the grass component is harvested 15 days before the tree-coppice shoot harvest, the grass do not face a severe competition from the tree for soil water and nutrients. The new tillers come up and attain height before the coppice shoot harvest. From the Tables 5 and 6 it can also be observed that in the H-3 harvesting schedule (subabul harvested at two month intervals and guinea grass 15 days later), the grass face severe competition from the tree component. This is because, in this harvesting schedule as the grass is harvested 15 days after the tree harvest, the production of new tillers and their height gain is dominated by the vigorous growth of coppice shoot that is taking place. During the last two harvests, the percentage rate of increase in height was more for the H-3 harvesting schedule along with the H-1 harvesting schedule (subabul and guinea grass harvested simultaneously, once in two months). These results indicate that by the sixth month; the grass has developed a root system, sufficient enough to compete with the tree, even if it is harvested after (H-3 harvesting schedule) or simultaneously with (H-1 harvesting schedule) the tree-coppice shoot harvest. However earlier literature to support this theory is scanty.

In all the comparisons the lowest rate of increase in height growth was given by the H-4 harvesting schedule (subabul harvested at two months intervals and guinea grass at 45 days intervals). Leopold (1949) and Cook and Stoddart (1953) had reported that as the clipping frequency was decreased; tillering was stimulated by the growth of the dormant lateral buds. This is presumed to be a reason for the reduction in the rate of increase in height; when the harvesting interval is reduced.

4.3. Tillering

4.3.1. Comparison between first and second season

Data on the rate of increase in tillering (%) of guinea grass in the second season (November-December) compared to the first season (September-October); for each harvest schedule are presented in Table 9. In this comparison; there was no significant variation for the intercropped and pure grass. Similarly, no significant variation was observed between the harvesting schedules above. The interaction effect was insignificant.

4.3.2. Comparison between second and third season

The data regarding the same parameter, compared between the third season (January-February) and second season (November-December) are given in Table 10. No significant variation was observed among the pure and intercropped plots of the grass. But significant variation was observed among the different harvesting schedules. The harvesting schedule (H-2) in which subabul was harvested every second month and guinea grass 15 days earlier showed the maximum rate of increase (33.52%); followed by H-3 harvesting schedule (subabul harvested every second month and guinea grass 15 days later) (28.79%), and the H-1 harvesting schedule in which guinea grass is harvested simultaneously along with subabul at two month intervals (27.30%). All the above three harvesting schedules were on par and was significantly superior; compared to the H-4 harvesting schedule (guinea grass harvested at 45 days interval) (20.27%). The interaction effect was insignificant.

Table 9. Comparison of percentage increase in tillering of grass between October and December 1987

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	17.22	25.00	20.75	20.99
H-2	17.24	31.71	26.69	25.21
H-3	23.09	17.03	18.67	19.59
H-4	14.07	11.55	14.73	13.45
Mean	17.91	21.32	20.21	

Spatial arrangement :NS Harvest schedule : NS
SEm :35.606

Table 10. Comparison of percentage increase in tillering of grass between December 1987 and February 88

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	25.50	25.10	31.29	27.30
H-2	28.45	34.98	37.12	33.52
H-3	30.40	25.28	30.70	28.79
H-4	16.27	22.10	22.44	20.27
Mean	25.16	26.87	30.39	

Spatial arrangement : NS Harvest schedule : S
SEm : 50.511 C.D. at 5% : 6.949

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Subabul planted at 1.5x1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-3 - Pure guinea grass

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass at 45 days intervals

4.3.3. Comparison between third and fourth season

Data for the parameter compared between the fourth season (March-April) and the third season (January-February) are given in Table 11. Significant variation was observed among the grass planted in pure and in intercropped plots. The rate of increase in tillering was maximum for the pure grass (31.44%) and this was significantly superior compared to the 27.61% of grass intercropped among subabul planted at 3 x 3 m spacing and the 23.83% of grass intercropped among subabul planted at 1.5 x 1.5 m spacing. The different harvesting schedules also indicated significant variation. The harvesting schedule (H-1) in which subabul and guinea grass were both harvested simultaneously once in two months gave a rate of increase of 32.74% which was on par with that got for the harvesting schedule (H-2), in which guinea grass was harvested 15 days earlier than subabul (31.8%). Both these, was significantly superior to the other rate of increase obtained for other harvesting schedules. Harvesting schedule (H-4) produced the least rate of increase (20.12%). The interaction effect was also found to be significantly higher.

4.3.4. Comparison between fourth and fifth season

In Table 12 data regarding the comparison of rate of increase in tillering (%) between the fifth season (May-June)

Table 11. Comparison of percentage increase in tillering of grass between February and April 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	39.92	23.83	34.47	32.74
H-2	24.93	31.14	39.33	31.80
H-3	23.24	19.37	34.91	25.84
H-4	22.33	20.99	17.06	20.12
Mean	27.61	23.83	31.44	

Spatial arrangement : S Harvest schedule : S
C.D. at 5% level : 3.645 C.D. at 5% level : 4.209
SEm : 18.530

Table 12. Comparison of percentage increase in tillering of grass between April and June 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	32.72	25.13	28.43	28.76
H-2	26.15	30.75	23.80	26.90
H-3	25.75	25.24	26.84	25.95
H-4	19.98	16.76	16.51	17.75
Mean	26.15	24.47	23.9	

Spatial arrangement : NS Harvest schedule : S
SEm : 16.024 C.D. at 5% level : 3.914

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Subabul planted at 1.5 x 1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-3 - Pure guinea grass

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass, at 45 days intervals

and the fourth season (March-April) are presented. Significant variation was only observed for the different harvesting schedules. The rate of increases obtained for all the harvesting schedules except the H-4 harvesting schedules (grass harvested at 45 days intervals) was found to be significantly superior and was on par with each other (28.76%, 26.9% and 25.95%). The interaction effect was not significantly different.

4.3.5. Discussion

From the Tables 9, 10, 11 and 12 it can be observed that significant variation was obtained only during the first comparison (first season - second season) and the third comparison (third season - fourth season). In the first case, maximum rate of increase was observed for the grass planted among subabul at 1.5 x 1.5 m spacing (21.32%), which was on par with that obtained for the pure grass (20.21%). The higher value obtained for the pure grass plot conforms to the conclusions made by Auda *et al*., Humphreys (1966) and Williams (1980) that tillering increases as light intensity increases. In the second case, a definite and significantly superior increase in rate of tillering was observed for the pure grass, which is also in concordance with the deductions of the scientists mentioned earlier. The reduction in the rate of increase can be also be observed (Table 11) as the tree crop density increases.

For all the harvesting schedules at different seasons, the H-1 harvesting schedule (both tree and grass harvested simultaneously at two month intervals) and the H-2 harvesting schedule (grass harvested 15 days earlier than tree harvest) showed better tiller production rate. This could be attributed to the difference in the amount of light intensity available to grass at different harvesting schedules. In the H-1 harvesting schedule; as both tree and grass are harvested simultaneously higher light intensity is made available to the developing grass sward in the initial stages compared to the other schedules, while in the H-2 harvesting schedule; the top canopy of coppice shoots is removed 15 days after grass harvest; so that for the remaining 45 days the grass sward get sufficient light intensity for proper tiller development. In the H-3 harvesting schedule (grass harvested 15 days after tree harvest), the grass get more light intensity only during the later part of its 60 day harvesting cycle. In the H-4 harvesting schedule also, the overhead canopy is there restricting the availability of light intensity for the greater part of the 45 days cycle. The positively correlated relationship between tiller development and light intensity propounded by scientists had been quoted earlier.

4.4. Leaf production

4.4.1. Comparison between first and second season

In Table 13 data regarding the rate of increase in the number of leaves produced (%); when compared between the first season (September-October) and second season (November-December) are presented. Significant variation was observed among the different harvesting schedules. The rates of increase obtained for the H-4 harvesting schedule (guinea grass harvested at 45 days interval); H-2 harvesting schedule (guinea grass 15 days earlier than subabul) and the H-1 harvesting schedule (both grass and tree harvested simultaneously) was found to be significantly superior over the other harvesting schedule; and was on par. The interaction effect of the parameter with crop combinations was found not significant.

4.2.2. Comparison between second and third seas...

Data on the comparison of rate of increase in leaf production between the second and third season (November-December and January-February; respectively) are presented in

Table 13. Comparison of percentage rate of increase in number of leaves produced of grass between October and December 1987

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	26.19	27.14	22.15	25.16
H-2	29.40	31.43	22.91	27.91
H-3	19.46	18.95	19.99	19.47
H-4	27.75	34.34	27.57	29.88
Mean	25.70	27.96	23.15	

Spatial arrangement : NS   Harvest schedule : S
SEm : 49.659   C.D. at 5% level : 6.890

Table 14. Comparison of percentage increase in number of leaves produced of grass between December 1987 and February 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	35.26	45.82	34.98	38.69
H-2	38.14	44.53	32.44	38.37
H-3	34.74	29.23	24.66	29.54
H-4	26.91	28.27	16.18	23.79
Mean	33.76	36.96	27.07	

Spatial arrangement : S   Harvest schedule : S
C.D. at 5% level : 6.472   C.D. at 5% level : 7.474
SEm : 58.434

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Subabul planted at 1.5x1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-3 - Pure guinea grass

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass, at 45 days intervals

Table 14. Significant variation was observed among grass planted with subabul (intercrop) and pure grass. Maximum rate of increase was observed for the grass intercropped with subabul (spacing 1.5 x 1.5 m) (36.96%) and for the grass intercropped with subabul (spacing 3 x 3 m (33.76%); which was on par. This was significantly superior to that obtained for pure grass (27.07%). The harvesting schedules also showed significant variation. The schedule H-1 in which both components were harvested simultaneously once in two months (38.69%) and H-2; in which the grass was harvested 15 days earlier than subabul (38.37%) was found to be on par and significantly superior over other schedules. The interaction effect was not significant.

4.4.3. Comparison between the third and fourth season

In Table 15 data regarding the above parameter in compared between the third season (January-February) and fourth season (March-April). No significant variation was observed for the different pure and intercropped treatments of grass. However, significant variation was observed for the different harvesting schedules. The rates of increase obtained for the harvesting schedules H-2 (guinea grass harvested 15 days earlier than subabul) H-3, (guinea grass harvested 15 days later than subabul) and H-1 (both harvested simultaneously) were found to be significantly superior and was on

Table 15. Comparison of percentage increase in number of leaves produced of grass between February and April 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	37.31	37.84	29.47	34.87
H-2	38.75	38.97	30.46	46.06
H-3	38.29	40.19	27.22	35.23
H-4	25.23	24.70	24.08	24.66
Mean	34.90	35.43	27.81	

Spatial arrangement : NS Harvest schedule : S
SEm : 81.598 C.D. at 5% level : 8.832

Table 16. Comparison of percentage increase in number of leaves produced of grass between April and June 1988

Spatial arrangement / Harvest schedule	S-1	S-2	S-3	Mean
H-1	33.70	40.17	36.28	36.72
H-2	31.20	39.41	33.19	34.60
H-3	33.56	29.03	28.34	30.31
H-4	24.30	20.53	24.66	23.16
Mean	30.69	32.29	30.62	

Spatial arrangement : NS Harvest schedule : S
SEm : 42.073 C.D. at 5% level : 6.342

Spatial arrangement:

S-1 - Subabul planted at 3x3 m spacing; and ten rows of guinea grass between adjacent rows of subabul
S-2 - Subabul planted at 1.5x1.5 m spacing; and five rows of guinea grass between adjacent rows of subabul
S-3 - Pure guinea grass

Harvest schedule:

H-1 - Subabul and guinea grass harvested simultaneously, once in two months
H-2 - Subabul harvested every two months; and guinea grass 15 days earlier
H-3 - Subabul harvested every two months; and guinea grass 15 days later
H-4 - Subabul harvested every two months; and guinea grass, at 45 days intervals

par with each other compared to the H-4 harvesting schedule (grass harvested at 45 days intervals). The interaction effect was not significant.

4.4.4. Comparison between the fourth and fifth seasons

Data regarding the same parameter is compared between the fourth season (March-April) and fifth season (May-June) and presented in Table 16. There was no significant variation among the pure and intercropped grass treatments. But significant variation was noticed among the different harvesting schedules. The maximum rate of increase in leaf production was noticed for the H-1 harvesting schedule (both tree and grass harvested simultaneously once in two months) (36.72%) and the H-2 harvesting schedule (grass harvested 15 days earlier than subabul) (34.60%). These two harvesting schedules were on par with each other and superior than the other harvesting schedules. The interaction effect was not significant.

4.4.5. Discussion

Conclusive results were not obtained with regard to whether the pure or intercropped grass treatments resulted in the maximum number of leaf production. Significant variation between there treatments was obtained only for the comparison between the second and third season (see Table 14). In this, both the intercropped from treatments proved to be significantly superior over the pure grass treatment. Previous literature also do not conclusively say that leaf production increases with increasing light intensity. Williams (1980) reported that variation in light intensity had little influence as the rate of leaves produced and that it is the quantity of light energy available to a sward of grass that is important with regard to dry matter production.

From the comparison of the harvesting schedules at different seasons, it was observed that at all seasons the harvesting schedule (H-1) (both grass and tree harvested simultaneously once in two months) and the H-2 harvesting schedule (grass harvested 15 days earlier than subabul) showed the maximum rate of increase in leaf production, compared to other schedules. This result is in conjunction with that obtained for tillering rate.

4.5. Growth of subabul

The rate of increase (%) for the parameters girth at collar, girth at breast height, mean length of shoots per pollard, girth at the base of coppice shoots and number of leaves per shoot of average length were compared between

Plate 9. Growth of coppice shoots 10 days after pollarding (spacing of subabul 3x3 m)

Plate 10. Growth of coppice shoots 30 days after pollarding (spacing of subabul 3x3 m)

Plate 9

Plate 10

Plate 11. Growth of coppice shoots 60 days after pollarding (spacing of subabul 3x3 m)

Plate 12. Growth of coppice shoots 10 days after coppicing (spacing of subabul 1.5x1.5 m)

Plate 11

Plate 12

Plate 13. Growth of coppice shoots 30 days after coppicing (spacing of subabul 1.5x1.5m)

Plate 14. Growth of coppice shoots 60 days after coppicing (spacing of subabul 1.5x1.5m)

Plate 13

Plate 14

different seasons and none of the parameters differed substantially, due to the relatively short term duration of the experiment.

4.6. Soil chemical properties

4.6.1. Soil organic carbon

There was a significant increase after the experiment in the organic carbon content of the soil and the increase was higher in the top 0-15 cm layer, than in the lower 15-30 cm layer in all cases (Tables 17 and 18). The highest content of organic carbon was recorded with the subabul-guinea grass intercrop; (subabul planted at 1.5 x 1.5 m spacing) (1.44%) after the experiment period. This was followed by subabul at 3 x 3 m spacing intercropped with guinea grass (1.07%) and pure subabul planted at 1.5 x 1.5 m spacing (0.95%); which was on par with each other. The above treatments were significantly different from that obtained for pure guinea grass (0.58%) and pure subabul planted at 3 x 3 m spacing (0.89%). Significant variation was not obtained for the organic carbon content in the lower 15-30 cm.

Table 17. Comparison of the difference in soil organic carbon (%) before and after the experimental period (0-15 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	0.44	0.06	0.13	0.85	0.44
Replication - Mean	R-1	R-2	R-3	-	-
	0.37	0.39	0.40	-	-

Treatments : S
C.D. at 5% level : 0.12
SEm : 0.038

Table 18. Comparison of the difference in soil organic carbon (%) before and after the experimental period (15-30 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	0.07	0.05	0.06	0.07	0.06
Replication - Mean	R-1	R-2	R-3	-	-
	0.06	0.06	0.06	-	-

Treatments : NS
SEm : 0.018

<u>Treatments</u>:

T-1 - Subabul planted at 3x3 m spacing; with ten rows of guinea grass between adjacent rows of subabul
T-2 - Pure subabul planted at 3x3 m spacing
T-3 - Pure guinea grass
T-4 - Subabul planted at 1.5x1.5 m spacing; with five rows of guinea grass between adjacent rows of subabul
T-5 - Pure subabul planted at 1.5 x 1.5 m spacing

4.6.2. Available Nitrogen

There was significant increase in the available N content in the top 0-15 cm soil layer and the bottom 15-30 cm layer, after the experiment (Tables 19 and 20). Pure subabul planted at 1.5 x 1.5 m spacing recorded the maximum rate of increase for the top 0-15 cm soil layer (2912 kg/ha). This was significantly higher compared to other treatments. This treatment was followed by intercropped subabul planted at 1.5 x 1.5 m spacing (2912 kg/ha) which was on par with the 3584 kg/ha of pure subabul planted at 3 x 3 m spacing. The least increase was obtained for pure guinea grass (2464 kg/ha) and intercropped subabul planted at 3 x 3 m spacing (2240 kg/ha), which was on par, obtained after the experimental period. Pure subabul planted at 1.5 x 1.5 m spacing topped in the available N content for the bottom soil layer (15-30 cm) also (2464 kg/ha), which was on par with that obtained for pure subabul planted at 3 x 3 m spacing (2912 kg/ha). This was followed by the treatments in which intercropped subabul was planted at 1.5 x 1.5 m spacing (2464 kg/ha), intercropped subabul planted at 3 x 3 m spacing (2464 kg/ha) and pure guinea grass (2016 kg/ha).

Table 19. Comparison of the difference in soil available Nitrogen (kg/ha) before and after the experimental period (0-15 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	214.67	632.67	256.67	668.00	812.67
Replication - Mean	R-1	R-2	R-3	-	-
	537.60	506.40	506.80	-	-

Treatments : S
C.D. at 5% level : 87.44
SEm : 26.813

Table 20. Comparison of the difference in soil available Nitrogen (kg/ha) before and after the experimental period (15-30 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	475.33	662.00	236.67	584.00	669.33
Replication - Mean	R-1	R-2	R-3	-	-
	537.60	512.00	526.80	-	-

Treatments : S
C.D. at 5% level : 76.91
SEm : 23.583

Treatments:

T-1 - Subabul planted at 3x3 m spacing; with ten rows of guinea grass between adjacent rows of subabul
T-2 - Pure subabul planted at 3x3 m spacing
T-3 - Pure guinea grass
T-4 - Subabul planted at 1.5x1.5 m spacing; with five rows of guinea grass between adjacent rows of subabul
T-5 - Pure subabul planted at 1.5x1.5 m spacing

4.6.3. Available P

Significant variation was observed between treatments; at both top and bottom soil layer (Table 21 and 22). In the top 0-15 cm soil layer, the P content for all treatments except for pure subabul planted at 3 x 3 m spacing, was found to be significantly superior and on par. In the bottom soil layer (15-30 cm) available P content showed a maximum rate of increase for the intercropped subabul planted at 1.5 x 1.5 m spacing. This was followed by pure grass treatment with a post experiment available P content of 42.36 kg/ha. Contrary to other cases, a decrease in available P content was obtained for pure subabul planted at 1.5 x 1.5 m spacing (32.88 to 25.08%).

4.6.4. Available K content

Significant variation was observed between treatments at both top and bottom soil layers; with regard to available K content. The maximum rate of increase in available K was observed for the intercropped subabul planted at 3 x 3 m spacing (80.14 kg/ha increase), followed by pure subabul planted at 3 x 3 m spacing (11.73 kg/ha increase) Table 23. All the other treatments recorded a decrease in the available K value after the experiment. A decrease of 58.9 kg/ha was

Table 21. Comparison of the difference in soil available Phosphorus (kg/ha) before and after the experimental period (0-15 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	18.75	11.32	19.12	17.99	18.31
Replication - Mean	**R-1**	**R-2**	**R-3**	**-**	**-**
	16.90	17.62	16.78	-	-

Treatments : S
C.D. at 5% level : 3.88
SEm : 1.190

Table 22. Comparison of the difference in soil available Phosphorus (kg/ha) before and after the experimental period (15-30 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	9.83	7.14	13.39	16.87	-5.79
Replication - Mean	**R-1**	**R-2**	**R-3**	**-**	**-**
	7.54	9.10	8.23	-	-

Treatments : S
C.D. at 5% level : 2.81
SEm : 0.862

Treatments:

T-1 - Subabul planted at 3x3 m spacing; with ten rows of guinea grass between adjacent rows of subabul
T-2 - Pure subabul planted at 3x3 m spacing
T-3 - Pure guinea grass
T-4 - Subabul planted at 1.5x1.5 m spacing; with five rows of guinea grass between adjacent rows of subabul
T-5 - Pure subabul planted at 1.5x1.5 m spacing

Table 23. Comparison of the differents in soil available Potassium (kg/ha) before and after the experimental period (0-15 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	11.73	80.14	-24.14	-58.90	-1.13
Replication - Mean	R-1	R-2	R-3	-	-
	-4.99	1.62	7.99	-	-

Treatments : S
C.D. at 5% level : 23.69
SEm : 7.254

Table 24. Comparison of the difference in soil available Potassium (kg/ha) before and after the experimental period (15-30 cm)

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	-18.55	58.83	-8.29	-12.79	9.65
Replication - Mean	R-1	R-2	R-3	-	-
	-2.20	-2.60	22.11	-	-

Treatments : S
C.D. at 5% level : 37.64
SEm : 11.541

Treatments:

T-1 - Subabul planted at 3x3 m spacing; with ten rows of guinea grass between adjacent rows of subabul
T-2 - Pure subabul planted at 3x3 m spacing
T-3 - Pure guinea grass
T-4 - Subabul planted at 1.5x1.5 m spacing; with five rows of guinea grass between adjacent rows of subabul
T-5 - Pure subabul planted at 1.5 x 1.5 m spacing

recorded for the treatment in which intercropped subabul was planted at 1.5 x 1.5 m spacing. From Table 24, it may be observed that the maximum rate of increase was noted for pure subabul planted at 3 x 3 m spacing (58.83 kg/ha); followed by the 9.65 kg/ha rate of increase for pure subabul planted at 1.5 x 1.5 m spacing. For the remaining treatments, a decrease was noticed after the experiment.

4.6.5. Discussion

The organic carbon content and available N content showed an increase after the experiment, for all treatments; and at both soil layers. This along with the definite increase in available P; act as an indicator of the soil ameliorating properties of subabul (National Research Council, 1984).

National Research Council (1984) also state that subabul fixes about 100-200 kg N/ha; annually. This is made available to the grass intercrop. The available K content followed an erratic pattern at different soil depths. While the rate of increase was maximum (80.14 kg/ha increase; see Table 23) for the top soil layer; it decreased in the bottom layer; for the treatment in which subabul at 3 x 3 m spacing was intercropped with guinea grass (-18.55 kg/ha, see Table 24).

Table 25. Comparison of the difference in soil pH before and after experimental period

Treatment - Mean	T-1	T-2	T-3	T-4	T-5
	0.08	0.28	-0.40	0.37	0.36
Replication - Mean	**R-1**	**R-2**	**R-3**	-	-
	0.14	0.15	0.13	-	-

Treatments : S
C.D. at 5% level : 0.10
SEm : 0.031

Treatments:

T-1 - Subabul planted at 3x3 m spacing; with ten rows of guinea grass between adjacent rows of subabul
T-2 - Pure subabul planted at 3x3 m spacing
T-3 - Pure guinea grass
T-4 - Subabul planted at 1.5x1.5 m spacing; with five rows of guinea grass between adjacent rows of subabul
T-5 - Pure subabul planted at 1.5x1.5 m spacing

So, from the present study; no conclusive result could be drawn on the available K status of the soil after the experiment.

Ta-Wei et al. (1986) found that after a forage harvest of subabul; the soil nutrient content had a positive change; which indicated that nutrient gain exceeded its removal. The findings with regard to organic carbon; available N, P and K in the top soil layer conforms to this.

4.6.6. Soil pH

In Table 25; data regarding difference in pH after the experiment, for various treatments are given. The maximum increase in pH was noticed for intercropped subabul at 1.5 x 1.5 m spacing, pure subabul planted at 1.5 x 1.5 m spacing and pure subabul planted at 3 x 3 m spacing. These were on par and significantly superior compared to other treatments. The pure guinea grass treatment recorded a decrease in pH after the experiment.

4.7. Biomass estimation

Data regarding the biomass content of sample trees belonging to three representative girth classes are presented in Table 26. The highest green fodder yield was obtained

Table 26. Biomass of sample trees belonging to three representative classes

Sample No.	Girth Classes (cm)	GBH (o.b) (cm)	Girth at collar (cm)	Total height (cm)	Fresh weight (kg)				
					Stem			Leaves	Pods
					5cm d.o.b.	1-5cm d.o.b.	1cm d.o.b		
1	16-20	17.9	25.8	6.40	17.40* (13.89)	2.28 (1.41)	2.15 (1.3)	2.75 (1.25)	1.15 (0.59)
2	20-24	22.2	27.3	8.80	12.70 (9.62)	3.5 (2.11)	1.95 (1.11)	2.5 (1.12)	0.95 (0.51)
3	24-28	24.5	30.0	9.50	23.50 (17.58)	11.50 (6.78)	3.00 (1.68)	3.75 (1.65)	N.A.

*Figures in parenthesis are oven dry weight (kg)

(3.75 kg/tree) for the girth class 24-28 cm. In the 20-24 cm girth class; the green fodder yield from the sample tree was less compared to that in the 16-20 cm girth class; inspite of the fact that the former is having a greater height (8.80 m) compared to the latter (6.40 m). This variation could be attributed to the increased stem weight and consequently increased rate of branching. The dry matter content corresponding to the fresh weight is also given in the Table. The dry forage production per tree of 1.65 kg was much less compared to the 3.23 kg/tree obtained by Reddy (1981), for Var. Cunningham. The low soil pH of 5.5 at the experimental site and the decreased growth rate that followed may be the reason for this.

In Table 27, the biomass of sample trees as a per hectare basis is also presented. Dry matter yields of 1.83 T, 1.39 T and 1.24 T were obtained for the girth classes 24-28 cm, 16-20 cm and 20-24 cms respectively.

Data of dry forage yields of composite sample of guinea grass taken for various harvesting schedules are presented in Table 28. The fresh weight of samples drawn was 100 g in all cases. In all the harvesting schedules, the dry matter content gradually decreased as the cuts progressed. But the green fodder yield increased with seasons The

Table 27. Biomass of sample trees on a per-hectare basis.

Sample No.	Girth classes (cm)	Oven dry weight (T)				
		Stem			Leaves	Pods
		5cm d.o.b	1-5cm d.o.b	1cm d.o.b		
1	16-20	15.43	1.57	1.44	1.39	0.66
2	20-24	10.22	2.34	1.23	1.24	0.57
3	24-28	19.53	7.53	1.87	1.83	N.A.

Table 28. Oven dry weight (gms) of composite samples of guinea grass taken for different harvest schedules (%)*

Cuttings / Harvest schedule	I	II	III	IV	Mean
H-1	29.97	27.03	26.74	26.62	27.59
H-2	28.17	27.08	27.06	25.60	26.98
H-3	31.23	26.38	25.58	25.42	27.15
H-4	30.48	25.10	24.80	24.32	26.18

H-1 - Subabul and guinea grass, both harvested once in two months

H-2 - Subabul harvested every two months and guinea grass 15 days earlier

H-3 - Subabul harvested every two months and guinea grass 15 days later

H-4 - Subabul harvested every two months; and guinea grass at 45 days intervals

*Fresh weight of composite sample - 100 g

Table 29. Biomass of guinea grass on a per hectare basis

Serial No.	Harvest schedule	O.D. weight (%)	Yield of green fodder per hectare per annum (T)	Yield of dry matter per hectare per annum (T)
1	H-1	27.59	30.77	8.49
2	H-2	27.00	34.68	9.36
3	H-3	27.15	31.22	8.79
4	H-4	25.77	27.58	7.11

reduction was more severe in the H-4 harvesting schedule compared to the other; on the cutting interval is only 45 days for the H-4 harvesting schedule, compared to the 60 days in others. Among the remaining harvesting schedules H-1, H-2 and H-3; H-1 (tree and grass harvested simultaneously) had the highest dry matter content. In Table 29; biomass of guinea grass on a per hectare basis is presented. The highest dry forage yield was obtained for the H-2 harvesting schedule and the lowest; for the H-4 harvesting schedule. The dry matter yields obtained in the experiment is low (9.36 T/year) compared to that obtained by Gill, A.S. and Patil B.D. (1985) for silvipastures which is 20-30 T/year.

4.8. Light intensity studies

The procedure of light intensity measurement on a plot is given in Figure 3.

In Figure 4; four graphs relating to low the light intensity varied in three plots having guinea grass are presented. Each graph indicate a particular time of observation viz. 10.20, 12.20, 14.20 and 16.20 MST. There was a steep rise in the lux value through the months. But; in all months, the intensity of sunlight received was higher in the

Plate 15. Tree canopy cover before final harvest (spacing of subabul 3x3 m)

Plate 16. Tree canopy cover before final harvest (spacing of subabul 1.5x1.5 m)

Plate 15

Plate 16

pure grass (open) plot; followed by the intercropped plot in which subabul was widely spaced at 3 x 3 m; and the intercropped plot in which the tree was closely planted at 1.5 x 1.5 m. The highest light intensity was received between 12.20 and 14.20 MST.

The diurnal variation in light intensity for any months, could be observed from the graphs in Figure 5. The steep rise in the amount of light intensity could be observed here also. Compared to that in the months December, February and March; the light intensity measured at 16.20 MST in January is lower than that taken at 10.20 MST. This is due to formation of rainclouds towards the evening of the day of observation.

In Figure 6, two graphs which indicate the relationship between the mean height and mean number of tillers/hill and the light intensity are given. In Figure 6(a), it could be seen that the mean height of a hill is inversely related to the increase in light intensity. The mean number of tillers increased with increasing light intensity (Figure 6(b). These results are in full conformity to the earlier observations made by Langer (1963); Davis and Lande (1964); Auda <u>et al</u>. (1966); Hymphreys (1966) and Williams (1980).

Fig 4 Relat onsh p between relative lux and month of - observation.

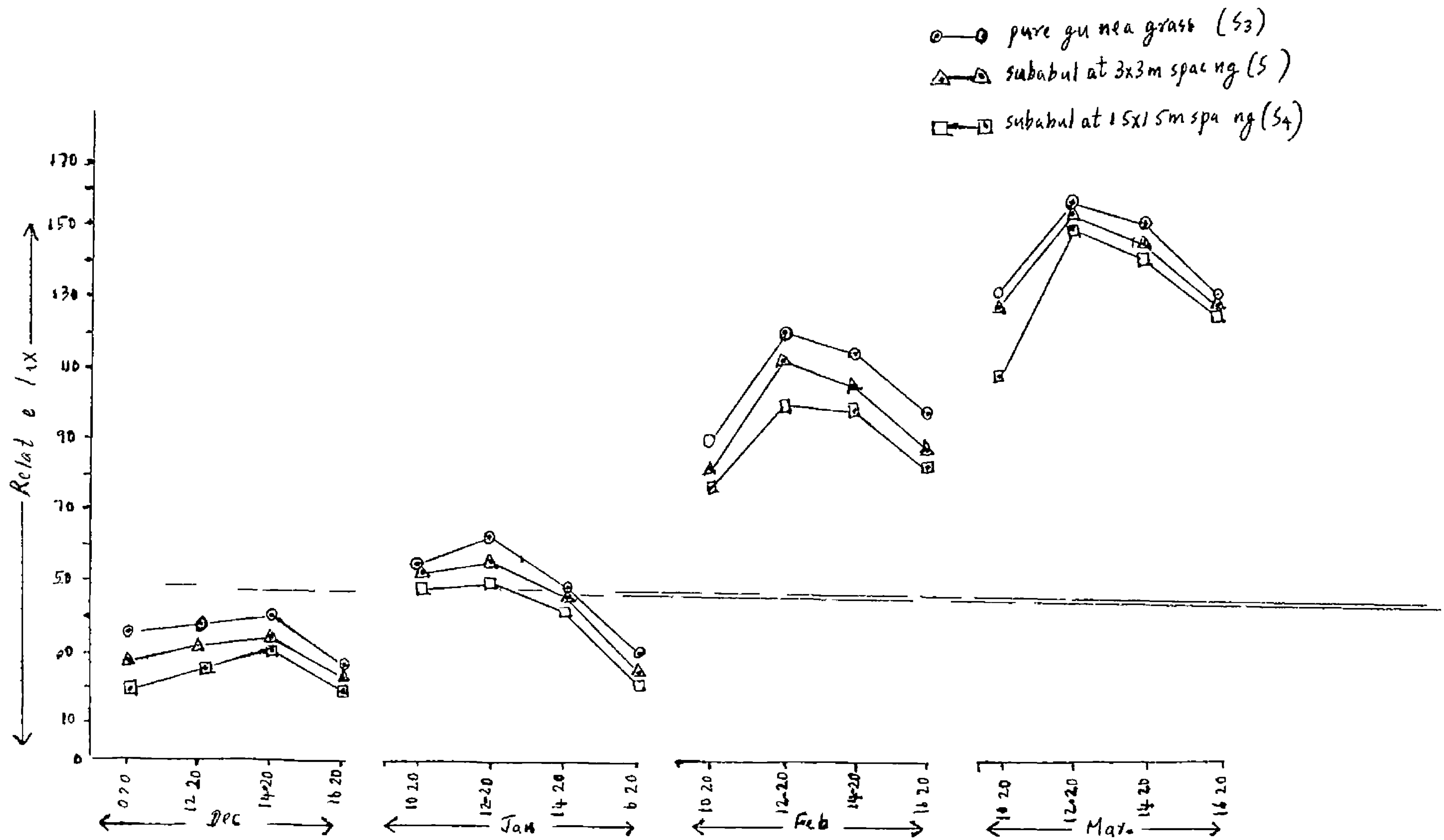


Fig 5 Relationship between relative lux and time of observation

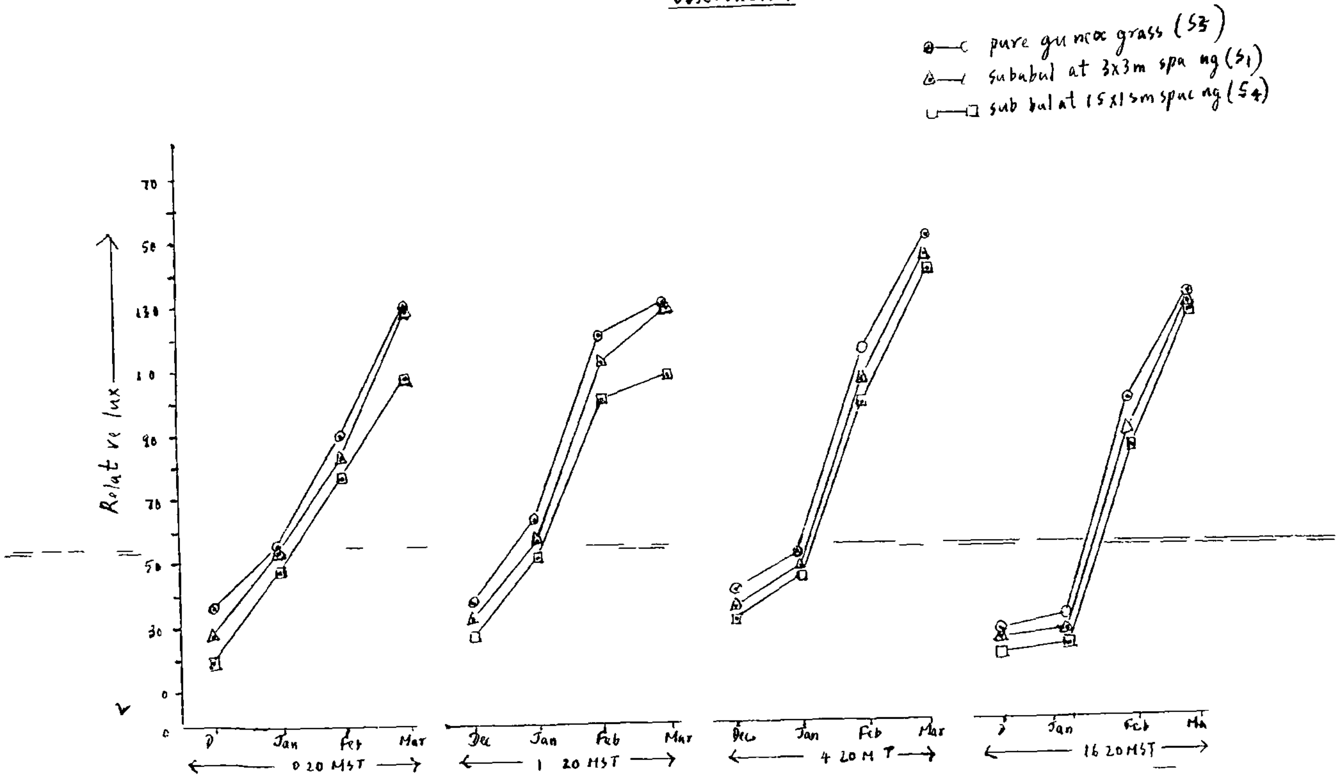


Fig 6(a)

Relationship between percentage rate of increase in mean height of grass and relative lux

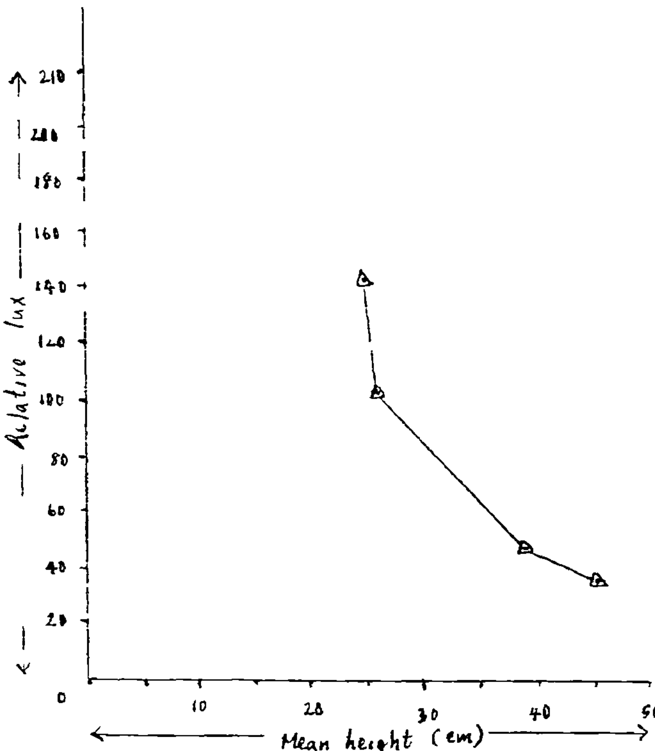
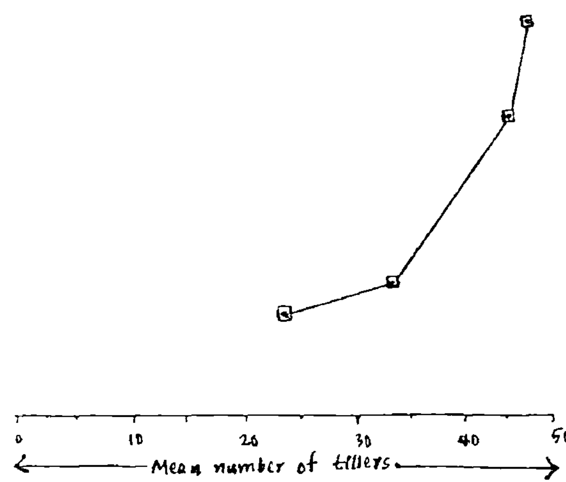


Fig. 6(b)

Relationship between percentage rate of increase in mean number of tillers of grass and relative lux



General Discussion

5. GENERAL DISCUSSION

The mean green fodder yield obtained from the intercropped plots was higher compared to the sole crop of either the tree or grass. Maximum green fodder yield was obtained from the H-3 and H-2 harvesting schedules.

Percentage rate of increase in height of guinea grass decreased under high light intensity situations, while that of tillering increased significantly. Tiller production was the maximum for the H-1 and H-2 harvesting schedules, as more amount of light is available for grass in its early stages of growth, in these schedules. Substantial variation was not noticed for the percentage rate of increase of leaf production, between the pure and intercropped treatments.

Growth observations of coppiced subabul, when compared did not indicate any significant variation which may be due to the short duration of the experiment.

Soil chemical analysis revealed that organic carbon and available N content increased after the experiment, which confirmed the soil ameliorating properties of subabul. The soil pH of intercropped treatments showed maximum increase.

Green fodder and dry matter yields of 3.75 kg and 1.65 kg/tree were obtained for the girth class 24-28 cm. This amounts to dry matter yields of 1.24 tonnes to 1.83 tonnes per hectare. Dry matter yields of guinea grass was 9.36 tonnes/hectare/year.

The light intensity increased steadily through the experimental period in all plots. The intensity of light was maximum between 12.20 and 14.20 MST.

Summary

SUMMARY

An investigation on "Spatial arrangement and harvesting schedule in a silvipastoral system" was undertaken at the social forestry plantation located at Viyoor, near Trichur from August 1987 to June 1988. The major objectives of the investigation were to find out the most suitable spatial arrangement of subabul and guinea grass, for maximising biomass production, to ascertain most suitable harvesting schedule of subabul and guinea grass to investigate the growth characteristic of subabul and to study the soil fertility aspects, associated with the crops.

The experiment was laid out in a factorial RBD with 5 spatial arrangements and 4 harvesting schedules as follows:

Spatial arrangements:

S-1 - 1.5 m between subabul rows and five rows of guinea grass in the alleys between two rows of subabul.

S-2 - 3 m between subabul rows and ten rows of guinea grass between two rows of subabul.

S-3 - Subabul pure crop at 3 x 3 m spacing.

S-4 - Subabul pure crop at 1.5 x 1.5 m spacing.

S-5 - Guinea grass pure crop; at 36 x 18 cm spacing.

<u>Harvesting schedules:</u>

H-1 - Harvesting both subabul and guinea grass simultaneously once in two months.

H-2 - Harvesting subabul every second months and guinea grass 15 days earlier.

H-3 - Harvesting subabul every second month and guinea grass 15 days later.

H-4 - Harvesting subabul every second months and guinea grass every 45th day.

The results obtained are summarised below:

1. Higher green fodder yields were obtained from the inter-cropped treatments compared to the sole crop of either the tree or grass.
2. Among the harvesting schedules H-2 and H-3 schedules recorded maximum green fodder yield.
3. Among the spatial arrangements S-1 recorded maximum green fodder yield.
4. Percentage rate of increase in height of grass decreased with increasing light intensity; while that of tillering showed a positive response.
5. Significant variation was not noted for the percentage rate of increase in leaf production, under varying light intensity situations.

6. Maximum light intensity was obtained between 12.20 and 14.20 MST.
7. Soil chemical analysis indicated that the organic carbon, available N and soil pH of the intercropped treatments increased after the experimental period.
8. Dry matter yields from subabul and guinea grass were 1.83 T and 9.36 T/ha/year, respectively.

References

REFERENCES

Auda, H., Blaser, R.E. and Brown, R.H. (1966). Tillering and carbohydrate content of orchard grass as influenced by environmental factors. Crop Sci. 6, 139-143.

Balasundaram, M. and Mohamed, A.M.I. (1987). Root Nodulation Potentialities of Leucaena leucocephala in Kerala, Kerala Forest Research Institute Research Reports-48, Kerala Forest Research Institute, Peechi 680 653, Kerala. pp 1-18.

Bhatia, N. and Promila, K. (1985). Regulation of branch numbers and dispersion in Leucaena leucocephala Leucaena Research Reports. 6:23-24.

Bhumibhanion, S., Boonarutee, P., Luangjanie, J. and Thavoru,N. (1984). Coppicing of Leucaena leucocephala (Lam.) de Wit. Leucaena Research Reports. 5:70.

Brewbaker, J.L. and Hutton, E.M. (1979). Leucaena: Versatile Tropical Tree Legume. New Agricultural Crops AAAS Selected Symposia Series. pp 207-257.

Chacko, K.C. (1984). Root system of some common trees. Evergreen. 13:25-26.

Coffinia, J.; Atta-Krah, A.N. and Dugumab. (1987). Evaluation of Leucaena accessions for tolerance to soil acidity. Leucaena Research Reports. 8:48.

*Cook, C.W. and Stoddart, C.A. (1953). Some growth responses of crested wheat grass following herbage removal. J. Range. Manage. 6:267-270.

Das, R.B. and Dalvi, G.S. (1981). Effect of interval and intensity of cutting of subabul (Leucaena leucocephala). Leucaena Research Reports 2:21.

* Das, S.; Jones, N. and Islam, M.A. (1985). Research trials on ipil-ipil in Bangladesh. Bano Vigyan Patrika. 14(½):42-48.

* Davis, L.A. and Lande, H.M. (1964). The development of tillers in Bromus mollis L. Crop Sci. 4:477-480.

Deb Roy, R. and Pathak, R.S. (1974). Silvipastoral Management. Indian Fmg. (Nov.):41-42.

Denton, F.H. and Nickell, T. (1985). Field measurements of giant leucaena growth - Rainfall and growth of giant leucaena - leucaena size, distribution and prediction of fast growers. Leucaena Research Reports 6:82-87.

Dutt, A.K. and Urmila, J. (1987). Effect of coppicing at different heights on wood production of Leucaena. Leucaena Research Reports. 8:27.

Forest Research Institute. (1983). Abridged Glossary of technical terms. Forest Research Institute and Colleges Dehra Dun. pp.13,23, 33-34.

* Garwood, E.A. (1969). Seasonal tiller populations of grass and grass/clover swards with and without irrigation. J. Br. Grassld Soc., 24:333-334.

Gill, A.S. and Patil, B.D. (1984). Leucaena leaves as a source of manure. Leucaena Research Reports. 5:26.

Gill, A.S. and Patil, B.D. (1985). Subabul for forage production under intercropping - a new approach. Indian Fmg. 35(6):37-40.

Gohl, B. (1981). Tropical feeds (Animal production and Health Services) No.:12. FAO, Rome. pp 174-175.

*Griffith, A.L. (1937). Annual Report on Silvicultural Research in the Madras Presidency for the years of 1936-37.

Gupta, M.P. (1980). Notes on Leucaena trials in North India. Leucaena Research Reports. 1:10.

Gupta, P.S., Khirwas, S.S. and Kripal, S. (1983). Koobabul - A promising fodder tree. Leucaena Research Reports. 31(10):21-22.

*Humphreys, L.R. (1966)., Pasture defoliation practice - A review. J. Aust. Inst. Agr. Sci. 32:93-105.

Humphreys, L.R. (1978). Tropical pastures of Fodder crops. Longman Group Ltd., London. pp 7-11.

Jackson, M.L. (1958). Soil Chemical Analysis. Prentice Hall Inc. 1 U.S.A. pp 498.

KAU (1986). Package of Practices Recommendations 1986. Kerala Agricultural University, Directorate of Extension, Trichur. pp

King, K.F.S. (1979). Keynote address - some principles of agroforestry, In: P.L. Jaiswal (Ed.), Proceedings of the Agroforestry Seminar, Imphal, May 16-18, ICAR, New Delhi. pp 17-26.

Krishnamurthy, K.; Munegouda, M.K. and Ramakrishnappa, K. (1986). Influence of frequency and cutting regimes as the growth and yield of subabul (Leucaena leucocephala). Mysore J. Agric. Sci. 20(2):

Kushalappa, K.A. (1984). Guide to sampling technique for biomass studies. My Forest. (Mar.):23-26.

Lahane, B.N.; Relwani, L.L.; Raina, A.K. and Gadekar, H.L. (1987). Initial evaluation of Leucaena leucocephala cultivars for fodder production. Leucaena Research Reports. 8:29-30.

Langer, R.H.M. (1963). Tillering in herbage grasses. Herb. Abstr. 33:141-148.

*Leopold (1949). The control of tillering in grass by auxin. Amer. J. Bot. 36:437-440.

Maeda, S. and Ehara, K. (1962). Physiological and ecological studies on clipping of herbage plants. Proc. Crop Sci. Soc. Jap. 39:313-317.

Mishra, V.K. (1986). Scope of Nitrogen Fixing Plants. In Proceedings of the Satellite Seminar on "Agroforestry Systems - A New Challenge" Jan.2, 1984. ISTS, Department of Forestry, Dr.Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan. 173 230. pp 213-218.

Mohatkar, L.C. and Relwani, L.L. (1985). Effect of plant Population, stubble height and number of cuttings on the growth, seed, forage and firewood production of leucaena K-8. Leucaena Research Reports. 6:40-41.

National Commission of Agriculture (1976). Part IX - Forestry. New Delhi, Government of India, Ministry of Agriculture and Irrigation.

National Research Council (1984). Leucaena - Promising forage and tree crop for tropics. National Academy of Sciences, Washington D.C., U.S.A. pp 1-85.

Olvera, E. and Blue, W.G. (1985). Establishment of Leucaena leucocephala in acid soils. Tropic. Agric. 62(1):73.

Panse, V.G. and Sukhatme, P.V. (1978). Statistical Methods for Agricultural Workers. 3rd Edn. ICAR, New Delhi, pp 347.

Pathak, P.S. and Deb Roy. (1987). Silvipastoral system for forage production on wastelands. Indian Fmg. 36(8):10-11.

Pathak, P.S.; Patil, B.D.; Gupta, S.K. and Deb Roy, R. (1981). Forage yield comparison in Leucaena leucocephala cultivars. Leucaena Research Reports. 2:26.

*Patil, B.D. and Pathak, P.S. (1977). Energy Plantation and Silvipastoral system for rural areas, Invention Intelligence. 12(1-2):79-87.

Plucknett, D.L. (1979). Improved pastures - Managing Pastures and cattle under coconuts. West View Tropical Agriculture Series No.2. pp 152-153.

Raina, A.K. (1983). Performance of subabul in India Arid Zone Leucaena in Silvipasture and Range Forestry. Leucaena Research Reports. 2 :34.

Rao, N. and Khan, K.A.R. (1981). Growth performance of subabul on lateritic mounds. Leucaena Research Reports. 2:27.

Raut, M.S. and Gill, A.S. (1987). Intercropping studies in Green Panic with forage shrubs. Leucaena Research Reports. 8:34.

Reddy, N.V. and Das, R.B. (1981). Adaptability trial of Leucaena leucocephala. Leucaena Research Reports. 2:29.

Relwani, L.L.; Rangnekae, D.V.; Joshi, A.L.; Deshmukh, S.S.; Khandale, D.V. and Nakat, R.V. (1984). Subabul for Fodder, Fuel and Timber. Indian Fmg. 34(1):21-23.

Relwani, L.L.; Lahane, D.N.; Khandale, D.Y. and Deshmukh, S.K. (1985). Performance of Leucaena leucocephala on mountainous wastelands under dry land conditions. Leucaena Research Reports. 6:49-50.

Srivastava, A.K. (1984). Agroforestry - its scope in rural development. In Proceedings of the Satellite Seminars on "Agroforestry Systems - A New Challenge". Jan.2; 1984. ISTS, Department of Forestry, Dr.Y.S.Parmar University of Horticulture and Forestry. Nauni, Solan. 173 230. pp 75-81.

Singh, P. (1987). Research on Fodder and Grass land makes headway. Indian Fmg. 36(8):3.

Ta-Wei Hu; Wei-Er Cheng and Tse-Au Shen. (1986). Changes in soil nutrients after forage harvest of Leucaena leucocephala. Leucaena Research Reports. 5: pp 68.

Thomson, D.A. (1985). Leucaena leucocephala trials in Jamaica. Leucaena Research Reports. 6:60-62.

Varghese, M.I. (1987). Subabul, Aranyam. Kerala Forest Department. Vazhuthacad, Trivandrum. 2(1): 27-30.

Wildin, J.H. (1985). Tree Leucaena - Permanent high quality pastures. Leucaena Research Reports. 6:103.

Williams, T.E. (1980). Grass - its production and utilization (ed) by W. Holmes, Blackwell Scientific publications, London. pp 10-26.

*Originals not seen

SPATIAL ARRANGEMENT AND HARVESTING SCHEDULE IN A SILVIPASTORAL SYSTEM

By

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ABSTRACT OF A THESIS

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ABSTRACT

An experiment was conducted in the Social Forestry plantation located at Viyoor, near Trichur from August 1987 to June 1988 to evaluate different spatial arrangements and harvesting schedules in a silvipastoral system. The crop components were subabul and guinea grass. The experiment, replicated thrice, was laid out in a factorial RBD with twenty treatments, involving five spatial arrangements and four harvesting schedules.

The results revealed that subabul-guinea grass inter-crop gave higher green fodder yields during the summer season compared to a sole crop of either species. Dry matter yields of 1.83 T and 9.36 T/ha/year were obtained from subabul and guinea grass, respectively.

The spatial arrangement in which subabul was planted at 1.5 x 1.5 m spacing with five rows of guinea grass between two adjacent rows of subabul and the harvesting schedules in which subabul was harvested every second month and guinea grass 15 days earlier or later recorded higher green fodder yields.

Percentage rate of increase in height of grass decreased with increasing light intensity, while tillering rate increased. Light intensity received during the experimental period steadily increased and the maximum lux readings were obtained between 12.20 and 14.20 MST.

Soil chemical analysis conducted before and after the experimental period indicated that the organic carbon, available N and soil pH of the intercropped treatments increased significantly. This proved the soil ameliorating properties of subabul.